The International Tin Research and Development Council consists of delegates appointed by the Governments of the principal tin-producing countries.

Its objects are to acquire and disseminate scientific and technical knowledge relating to tin, its alloys and chemical compounds, and their production and uses.

The Council co-operates in research and other activities to discover and develop new uses of tin, and to assist tin users in overcoming their difficulties and problems.

Inquiries are welcomed, and no charge is made for information or assistance.

HISTORIC TINNED FOODS

PUBLICATION NUMBER 85

(*Second Edition*)

INTERNATIONAL TIN RESEARCH AND DEVELOPMENT COUNCIL
FRASER ROAD, GREENFORD
MIDDLESEX, ENGLAND

PREFACE

This book originated in a letter to *The Times*, in March, 1937, in which J. C. Drummond, Professor of Biochemistry at University College, London, sought to renew contact with the donor of four canisters of dried vegetables which had been packed for the Crimean War.

The letter led to this Council making a search for relics of a similar kind which brought to light two cans filled, one with roasted veal and the other with carrots, nearly 114 years earlier. The cans were in the Royal United Services Museum and the National Maritime Museum in London, and had formed part of the stores taken by Sir Edward Parry on his Third Expedition in search of the North West Passage in 1824. Cans of 86 and 58 years of age were also found in the National Maritime Museum and included in the investigations which began in February last year.

The five papers reproduced in this volume were read before the Food Group of the Society of Chemical Industry in London on April 13, 1938, and published under the title *The Examination of some Tinned Foods of Historic Interest* in the Society's *Chemistry and Industry* (Vol. LVII, pp. 808-814, 827-836, 914-917). By kind permission they have been reprinted verbatim and issued as Publication 85 of this Council. In this, the second, edition the text remains identical with the original but the papers are in a different order and the opportunity has been taken to use a shortened form of title, to index and number the sections and to insert additional illustrations.

JOHN IRELAND,

July, 1939. *Director of Development,*

International Tin Research and Development Council.

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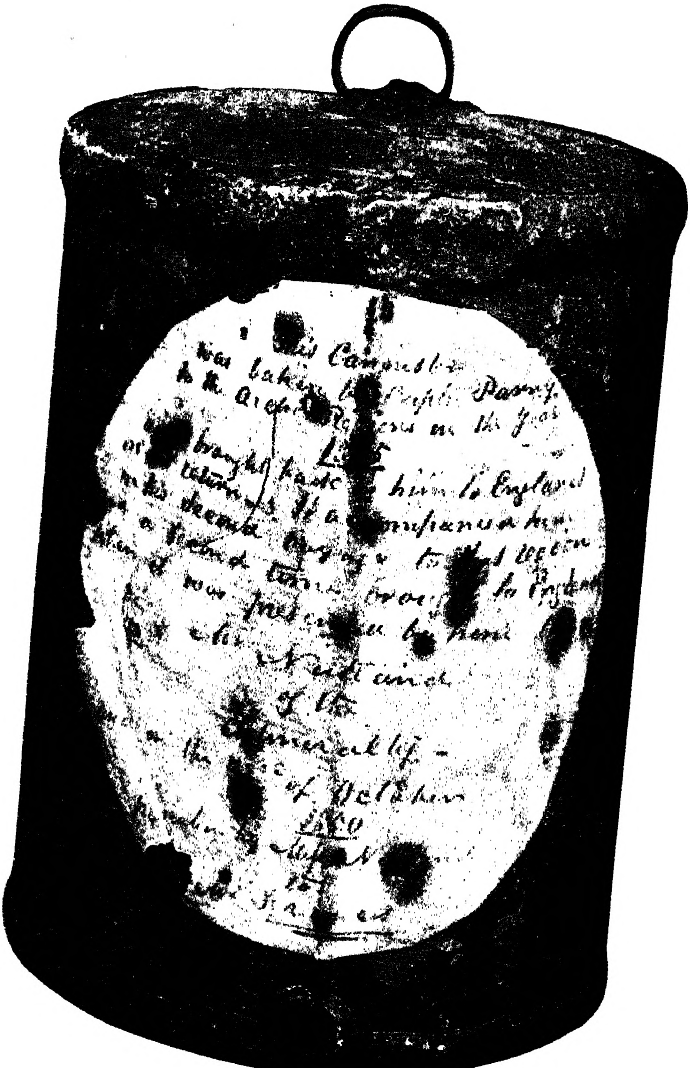


Can of roast veal 1824

PART I

HISTORICAL INTRODUCTION

By PROF. J. C. DRUMMOND, D.SC., F.I.C., *and*
W. R. LEWIS, B.SC.

¶1 Appert's Researches

It was undoubtedly Nicholas Appert working quietly in his little house at Massy (Seine et Oise) during the troubled years at the end of the 18th century who laid the foundations of our modern canning industry. The four stages of his process are clearly described by him.

1° A renfermer dans les bouteilles ou bocaux les substances que l'on veut conserver;
2° A boucher ces différents vases avec la plus grande attention; car, c'est principalement de l'opération du bouchage que dépend le succès;
3° A soumettre ces substances ainsi renfermées, à l'action de l'eau bouillante d'un bain-marie, pendant plus ou moins de temps, selon leur nature et de la manière que je l'indiquerai pour chaque espèce de comestible;
4° A retirer les bouteilles du bain-marie au temps prescrit.

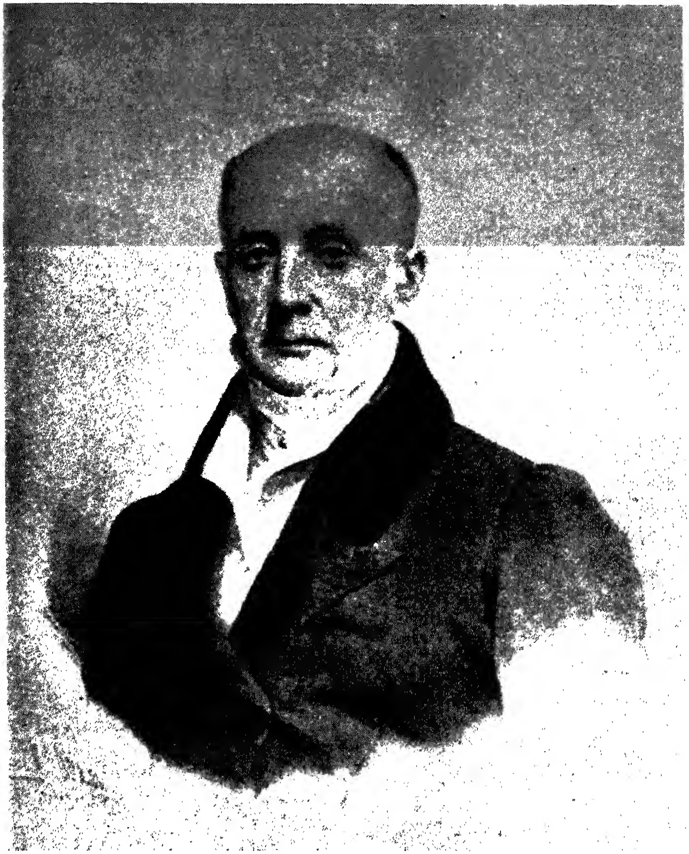
Although his stout glass bottles were stoppered before heating, it is quite clear from his book that he held the current view, and it must be remembered that it governed all practice until towards the end of the 19th century, that contact with air is the chief cause of putrefaction. Appert's preparations, a wide range of meats, vegetables, fruits, and even milk, were tried out experimentally by the French Navy about 1806 and apparently proved successful. Certainly, three years later, he was rewarded with a prize of 12,000 francs by the Bureau Consultatif des Arts et Manufactures. In 1810 his famous work appeared, "Le Livre de tous les Ménages ou l'Art de Conserver pendant Plusieurs Années Toutes les Substances Animales et Végétales."

Nicholas Appert (1750-1840)

¶2 The First Tinned Foods

In the following year a process clearly based on that of Appert was developed in England by John Hall, founder of the famous Dartford Iron Works, and his associate, Bryan Donkin. It is not quite clear how this occurred. In a history of the firm of J. & E. Hall, Ltd.,* it is stated that John Hall and his associates paid £1,000 for "a French Patent by a Chemist named Appert," but, in the first place, there was no patent, and, secondly,

*J. and E. Hall, Ltd., 1785–1935, by Everard Hesketh, 1935.



Bryan Donkin, F.R.S. (1768-1855)

the records of the firm of Chevallier-Appert,* which still flourishes in Paris, contain no account of the transaction. Whatever may be the truth of this, it is certain that the directors of the flourishing new enterprise at Dartford saw a promising

*Information kindly supplied by M. Zwilling of the Maison Chevallier-Appert, Paris.

outlet for their products if iron containers could be used instead of glass. One suspects that it was Bryan Donkin, a born investigator and inventor, and a Fellow of the Royal Society, who had this vision and who, therefore, can be regarded as the father of the modern canning industry.

Although Augustus de Heine (English Pat. No. 3310 of February 26, 1810) and Peter Durand (English Pat. No. 3372 of August 25, 1810) had patented the use of iron and tin containers respectively for preserving foods, neither of them engaged in canning on a commercial scale.

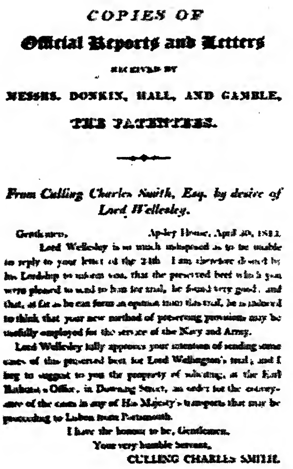
¶3 Early Trials by the Navy

A year or so of experimentation with many failures passed before the difficulties had been so far overcome that Donkin and Hall's new factory in Blue Anchor Road, Bermondsey, could send tins of preserved foods to high authorities of the Navy and Army for trial. From correspondence during 1813 we know they were attracting favourable attention. Supplies were sent to some stations, St. Helena, for example, in 1814, and in the same year we learn that Admiral Cochrane, commanding the West India Station, asked that some of the "patent preserved meats" should be sent out for trial as part of the diet of the sick sailors; he having been informed that the "soup and bouilli" would keep fresh even in the West Indies.

¶4 Testimonials prior to 1817

There is a record of a letter, dated April 30, 1813, from a certain Culling Charles Smith, writing on behalf of Lord Wellesley (later, Duke of Wellington), to say that his Lordship found the preserved beef very good; it was perhaps a little tactless for this amanuensis to add that his Lordship could not write himself owing to his being so much indisposed.* Many other testimonials to the quality of Donkin and Hall's preserved foods are contained in the brochure which the firm issued in 1817, among them one from the lordly Sir Joseph

*Copies of Official Reports and Letters relative to Donkin, Hall and Gamble's Preserved Provisions. London. 1817.


COPIES OF

Official Reports and Letters

RECEIVED BY

MESSRS. DONKIN, HALL, AND GAMBLE,

THE PATENTEES.

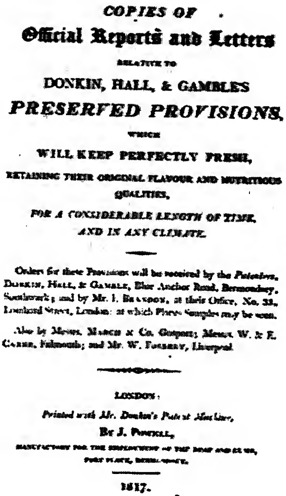
From Culling Charles Smith, Esq. by desire of Lord Wellesley.

Gentlemen, Apsley House, April 30, 181[illegible]

Lord Wellesley is so much indisposed as to be unable to reply to your letter of the 24th. I am therefore directed by his Lordship to inform you, that the preserved beef which you were pleased to send to him for trial, he found very good; and that, as far as he can form an opinion from this trial, he is induced to think that your new method of preserving provisions may be usefully employed for the service of the Navy and Army.

Lord Wellesley fully approves your intention of sending some cases of this preserved beef for Lord Wellington's trial; and I beg to suggest to you the propriety of applying, at the Earl Bathurst's Office, in Downing Street, an order for the conveyance of the cases in any of His Majesty's transports that may be proceeding to Lisbon from Portsmouth.

I have the honour to be, Gentlemen,
Your very humble Servant,
CULLING CHARLES SMITH.


COPIES OF

Official Reports and Letters

RELATIVE TO

DONKIN, HALL, & GAMBLE'S

PRESERVED PROVISIONS,

WHICH

WILL KEEP PERFECTLY FRESH,

RETAINING THEIR ORIGINAL FLAVOUR AND NUTRITIOUS QUALITIES,

FOR A CONSIDERABLE LENGTH OF TIME, AND IN ANY CLIMATE.

Orders for these Provisions will be received by the *Patentees*, Donkin, Hall, & Gamble, Blue Anchor Road, Bermondsey, Southwark; and by Mr. [illegible], at their Office, No. 33, Lombard Street, London: at which Places Samples may be seen.

Also by Messrs. [illegible] & Co. Gosport; Messrs. W. & E. [illegible], Falmouth; and Mr. W. [illegible], Liverpool.

LONDON:

Printed with Mr. Donkin's Patent Machine,

By J. [illegible],

[illegible]

1817.

Lord Wellesley's Testimonial

Banks, then President of the Royal Society. Writing from Revesby Abbey in 1814 he says:

> I know of no objection to my name being placed among the very respectable names which are printed in your Prospectus, as giving their testimony in favour of the nutritious qualities of your embalmed Provisions.

A little later, July 15, 1815, he is writing again to say that the fillet of veal which had been canned since December, 1812, and sent to him in January, 1813, had been opened and consumed. The contents were "declared by the unanimous vote of the party present . . . to be in a perfect state of preservation, and had not lost any of its nutritious qualities."

Some of Donkin's products were taken on the expedition in H.M.S. *Isabella* and *Alexander* to Baffin's Bay in 1814. The ships were furnished with flour, beef, pork, suet, oatmeal, raisins, sugar, cocoa, butter and cheese, lemon juice and

"preserved meats," "vegetable soup," "concentrated soup." The commander, John Ross, noted in his diary on September 8 that as the store of vegetables had been expended, orders were given for serving a proportion of these preserved foods in lieu of part of the salt provisions, in order to prevent scurvy. Parry was a lieutenant in *Alexander* on this trip. He gave his men 1 lb. of preserved meat and 1 lb. of vegetable soup a week.

¶ 5 Portable Soups in Cakes

In June, 1815, Admiral Cochrane reported most enthusiastically on the preserved foods which had been sent out to the West Indies at his request. One of his officers, Mr. Grimstone, surgeon in H.M.S. *Tennant*, reported that they were far superior to the "portable soup" which had been tried for seven years, but had not been found a success. This brought a prompt reply from Donkin and his associates to the effect that they had "never put up Portable Soups in cakes, the sort alluded to by Mr. Grimstone."

We have not succeeded in tracing who prepared this "portable soup," but it is likely that it was a preparation of the same character as that carried by Captain Cook in his voyage round the world in 1772–75, which he found was a valuable food for sick sailors when mixed with pease flour.

According to Sir John Pringle, it was made by removing the fat from meat broth and evaporating—

> having by long boiling evaporated the most putrescent parts of the meat, is reduced to the consistence of a glue, which in effect it is, and will like other glues in a dry place keep sound for years together.*

Cook gave his men 1 ounce boiled with pease three days a week.

The list of "Assortment of Medicines to be carried to sea, for One Hundred men, for one year" given as an appendix to Gilbert Blane's "Observations on the Diseases of Seamen" (2nd edition, 1789) includes 50 lb. of "Portable soup." It

*A Discourse upon some late Improvements of the Means for Preserving the Health of Mariners. Sir J. Pringle. 1776.

was to be in charge of the Purser, and served out "to the Sick in place of the common sea provisions."

A small amount of a cake of "portable soup" which has been for many years in the Museum of the United Services Institution and, it is believed, was part of Cook's stores, has come into our possession through the generosity of the Curator, Colonel E. L. Hughes. A report on its composition is given in Part II.

¶6 A Navy Contract of 1818

By 1818, Messrs. Donkin, Hall, and Gamble were supplying considerable amounts of their preserved foods to the Admiralty Victualling Depot of Deptford. The following list shows the quantities delivered between March and December of that year.

Item	*Quantity* *lb.*	*Size of can* *lb.*	*oz.*	*No. of cans (calculated)*
Mess beef..	9,237	1	6	6,700
Corned round of beef	1,289	2	3	590
Roasted beef	690	2	6	290
Seasoned beef	455	2	3	208
Boiled beef	609	2	0	305
Boiled mutton	8,227	2	3	3,780
Seasoned mutton	186	2	3	85
Mutton and vegetables	66	2	3	30
Boiled veal	4,489	2	6	1,890
Roasted veal	1,066	3	0	355
Veal and vegetables	1,024	2	6	432
Soup and bouilli	5,498	2	0	2,749
Vegetable soup	4,420	4	0	1,105
Mess beef and vegetables	4,684	1	6	3,400
Concentrated soup	4,420	2	6	1,860
Total	46,360			23,779

The total cost was £5,481 4*s*. 1*d*., which gives an average of 2*s*. 4½*d*. a pound. There were 440 cases, representing an average of 54 canisters in a case. Of the whole amount no

Captain Sir Edward Parry

less than £1,642 worth was earmarked for the use of ships voyaging to the Arctic Circle. The reference to "Soup and Bouilli" reminds us that our familiar word bully-beef is derived from the seamen's efforts to pronounce the name of this dish.

¶ 7 Tinned Foods in Arctic Explorations

Actually at this time Donkin's preserved meats had been tried out in the Arctic with success, for Otto von Kotzebue took some with him on his voyage to the North-West Passage in 1815. The Russian explorer had heard of "a discovery lately made in England" which seemed to him to be "too important not to be made use of for the expedition." He was delighted with the "tin boxes" he took and found their contents in excellent condition, whereas the preserved (probably dried) provisions which he took with him on the recommendation of the Economic Society of St. Petersburg went bad.*.

*We are greatly indebted to Mr. Lionel Foster, the well-known authority on Maritime History, for drawing our attention to the record of v. Kotzebue's experience.

¶8 Medical Testimonies in 1820

In 1819 Parry sailed on his first voyage of discovery of the North-West Passage. Donkin's provisions formed part of the stores taken in *Hecla* and *Griper*. They gave every satisfaction, proving particularly valuable on the sledge journey across Melville Island to the Northern shore. Here are the reports of the two surgeons.

H.M. Ship *Hecla*,
December 9, 1820.

. . . for my opinion of the preserved meats and soups supplied by Messrs. Gamble & Co. . . . I beg leave to state that I consider them to have been acquisitions of the highest value and I believe that the substitution of those articles for a considerable portion of the salt meat usually allowed in the service was one of the principal causes of the general good state of health that prevailed among the crews of both vessels. I am also happy in testifying to the general good quality of those provisions as well as to the perfection of the antiseptic process employed by Messrs. Gamble & Co. by which their meats and soups continued in an unimpaired state of preservation to the end of the voyage. I have the honour to remain, etc.

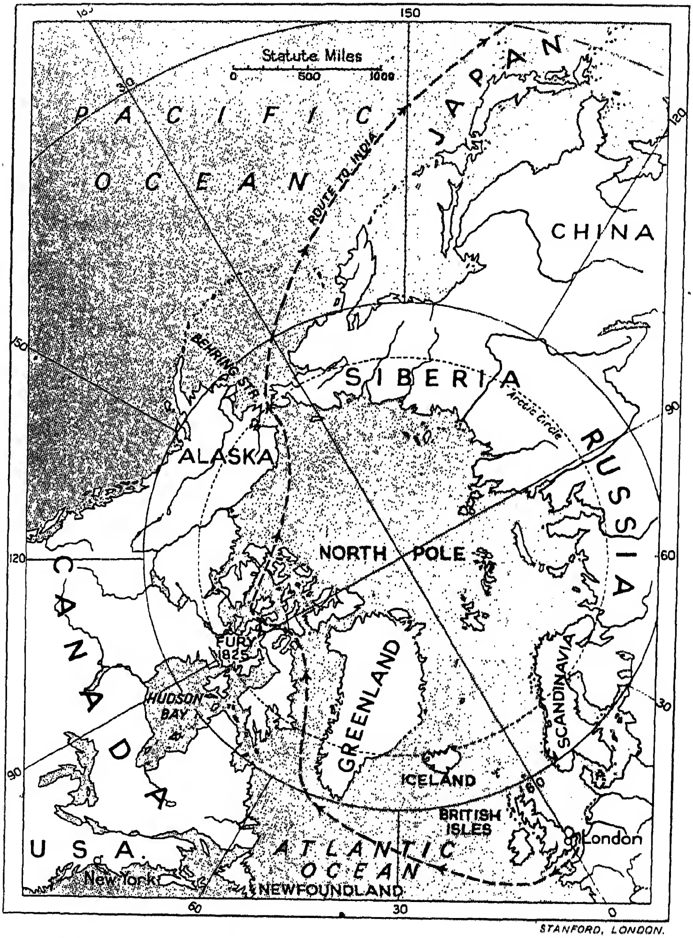
(Sgd.) JOHN EDWARDS,
Surgeon.

Griper,
December 9, 1820.

. . . I have no hesitation in pronouncing my opinion that to the judicious employment of these articles is to be attributed in great measure, the preservation of the general health of the Officers and Crew of H.M. Brig *Griper*, and to the same means is to be ascribed the recovery of the individual attacked by the scurvy.

The soups I consider peculiarly excellent, especially as I have every reason to believe that the antiscorbutic quality of the vegetable is not injured in its preparation. Etc., etc.

(Sgd.) C. I. BEVERLEY,
Asst. Surgeon.



The North-West Passage from the Atlantic to the Pacific

¶ 9 Some Early Contracts

On the second voyage—H.M.S. *Hecla* and *Fury*—even larger quantities of these foods were requisitioned. The list, in Parry's own handwriting, is a long one and contains the striking item of 10,000 lb. of preserved carrots. The explorer commented:

> and such indeed was the unbounded liberality with which all our supplies had been furnished particularly in the important article of Donkin and Gamble's preserved meats, which contain great nourishment in small bulk.*

Once again their excellence was proven.

When we come to the plans for the third expedition in 1824 two interesting points are worthy of comment. In the first place Donkin and Gamble are faced with competition, and secondly, there is the suggestion that larger tins than the 2 lb. and 4 lb. "packs" formerly made would be a convenience.

H.M. Ship *Hecla*,
February 2, 1824.

Captain Parry

to

The Commissioners for Victualling in London.

Since I last had the honour of communicating with your board I have tasted most of the various kinds of meat prepared by Messrs. Gamble & Co., and beg to recommend that the supply to be furnished to the *Hecla* and *Fury* consist of the description hereafter mentioned. The proportion of beef to be of four different kinds, viz. boiled, seasoned, roast and corned round of beef, an equal quantity of each. The mutton and veal to be 'boiled.'

With respect to what proportion of the above may be supplied by Mr. Morrison, I would beg to observe that I am induced to give Messrs. Gamble & Co. the preference from the idea that their mode of preparation has already been sufficiently tried to leave no doubt of its efficacy.

*Journal of a Second Voyage for the Discovery of a N.W. Passage, 1824. W. E. Parry.

February 3, 1824.

Tender from John Gamble & Co. for supplying

			s. d.	
5,000 lb.	Corned round of beef	at	1 8	lb.
5,000 ,,	Seasoned beef ..		1 9	,,
5,000 ,,	Boiled beef ..		1 2	,,
5,000 ,,	Roasted beef ..		2 0	,,
10,000 ,,	Boiled veal ..		2 0	,,
10,000 ,,	Boiled mutton ..		1 0	,,
9,000 qts.	Vegetable soup ..		3 0	qt.
12,000 lb.	Preserved carrots..		8	lb.
8,000 ,,	Preserved parsnips		1 2	,,

Meats were to be in 4, 6, 8, 12, and 20 lb. tin cases and the soup in ½-gallons and quarts. These were to be supplied by "25th March ensuing," only 50 days ahead, under a 12-month guarantee.

On February 4, they also put in a tender for 4,000 lb. beef (4 kinds) and 2,000 lb. each of mutton and veal for the *Griper*, to be supplied at the same time; all these quantities were ordered. At Parry's request, the tins were to hold exactly 4, 6, or 8 lb. for ease in issuing.

The firm of Morrison prepared a "portable soup," of which 510 lb. were taken in *Hecla* and *Fury*. There was also at the same time an application from a certain James Cooper of Clerkenwell, asking to be allowed to supply part of the preserved fresh provisions and stating that he had made some for Captain Luke of H.M.S. *Perseverance*, recently voyaging in the South Seas.

Some of the tins of Donkin's meats were landed on the ice when *Fury* met her fate in August, 1825. The dumps were found by Ross on his expedition of 1829–33,

> where the preserved meats and vegetables had been deposited, we found everything entire. The canisters had been piled up in two heaps . . . they had not suffered nor rusted . . .*

The contents were found to be in perfect condition. (*See also* ¶21.)

Donkin and Gamble's competitors were given a chance in the fitting out of the fourth expedition in 1826. Parry arranged contracts for the following amounts:—

*Voyage of Discovery in Search of a North West Passage, 1829–33. Sir John Ross.

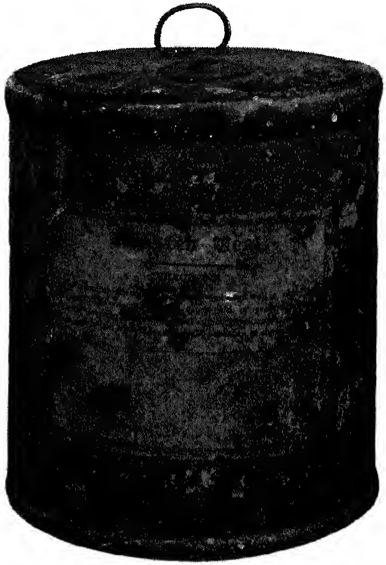
Preserved meats :	Boiled beef	2000 lb.
	Seasoned beef	2000 ,,
	Roast beef	2000 ,,
	Corned beef	1500 ,,
	Boiled mutton	2000 ,,
	Boiled veal	1600 ,,
Preserved carrots		1500 ,,
Preserved parsnips		1000 ,,
Table vegetables (Cooper's)		1500 ,,
Turnips		500 ,,
Vegetable soup		1720 qt.

(in quantities of 1 and 2 qt., equal numbers)

He suggested that Gamble, Cooper, and Morrison should each supply a third, and added: "It will be necessary to caution Mr. Morrison to have his canisters made of stronger tin than before." He wished Gamble to supply all the soups, but cautions Gamble "not to allow them to have that disagreeably acid taste which much of his furnishing before had. This was, I understand, said to arise from the late season of the year at which they were ordered (February), preventing his procuring the vegetables in their best state; an excuse which cannot now be urged."

¶ 10 An Unauthorised Repast

Two tins of 1826 have their history recorded in the Journal of the Royal Society of Arts of 1867. These were tins of meat left over from the stores of H.M.S. *Blonde* which went on a discovery voyage to the Sandwich Isles in 1826. They came into the possession of a jeweller named Hamlet, who in 1831 gave them to Dr. Alfred S. Taylor for analysis. In 1846 he opened one before the chemistry students at Guy's Hospital and noted that it seemed perfectly preserved. He was deprived of the opportunity of making a proper analysis by the action of some hungry hospital assistants who suffered no ill-effects from their unauthorised repast. In 1867, the remaining tin being then 41 years old, he opened it at the Society of Arts. The contents were in a partially decomposed condition due, as he says, to the rust having perforated the can some years before. He suggested that cans should be lacquered or painted on the outside to prevent rusting.

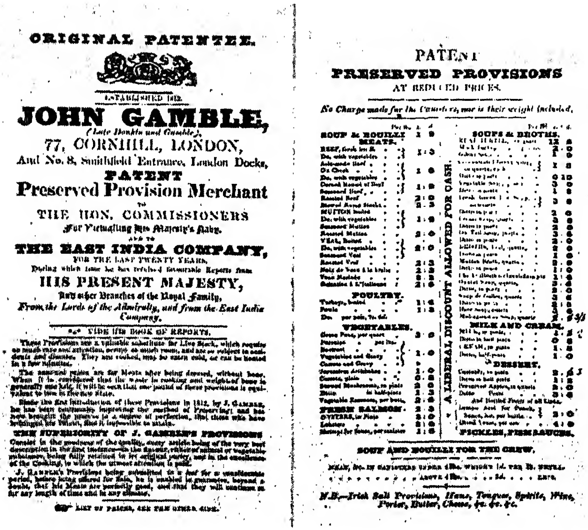


Can of roast veal taken on Parry's voyage in 1824
(See Frontispiece also)

¶ 11 Veal and Carrots 114 Years Old

Two canisters of Donkin and Gamble's preserved foods have come into our possession. One was a 4-lb. tin of "roast veal," which formed part of the stores of *Hecla* on the third voyage in 1824 and was brought home and taken out again to the Arctic on the fourth voyage in 1826. Unopened, it has been for many years in the Museum of the Royal United Services Institution. We are greatly indebted to the Council and the Curator, Colonel E. L. Hughes, for permission to open it and inspect the contents. The other, a 2-lb. tin of "carrots and gravy," was also taken on the third voyage in *Hecla* in 1825. Ultimately it became an exhibit in the National Maritime Museum at Greenwich. We wish to express our gratitude to Prof. Sir Geoffrey Callender and the Trustees of the Museum for their permission to open it.

The experience gained on these Arctic voyages was so con-



Public Record Office

A price list of about 1837

vincing that preserved foods were added to the list of "medical comforts" carried by H.M. ships in 1831.

A writer in 1841 in the Encyclopædia Britannica says that Donkin, Hall and Gamble had invented the following very ingenious method of testing the provisions put up by them:

> The cases thus hermetically sealed are exposed in a test chamber, for at least a month, to a temperature above what they are ever likely to encounter, from 90° to 110° F. If the process has failed, putrefaction takes place and gas is evolved, which in the course of time will bulge out both the ends of the case, so as to render them convex instead of concave. But the contents of whatever cases stand this test will infallibly keep perfectly sweet and good in any climate and for any length of time.

Donkin and Gamble found that the waste in cooking and boning meats was about half, and their products at 1*s*. 8*d*. to 3*s*. per lb. were therefore really economical. A number of

products packed in 1837 by the firm of J. H. Gamble & Co. which succeeded them are shown on their price list.

¶12 Appreciation of Tinned Foods in the Navy

The testimony of Captain Basil Hall of this period* shows how canned meats and provisions appealed to the Navy:

> It is really astonishing how good the preserved milk is . . . and you must, on examining the prices, bear in mind that meat thus preserved eats nothing, nor drinks—it is not apt to die—does not tumble overboard or get its legs broken or its flesh worked off its bones by tumbling about the ship in bad weather—it takes no care in the keeping—it is always ready, may be eaten hot or cold, and this enables you to toss into a boat as many days' cooked provisions as you require—it is not exposed to the vicissitudes of markets, nor is it scourged up to a monstrous price as at St. Helena, because there is no alternative. Besides these advantages it enables one to indulge in a number of luxuries which no care or expense could procure.

¶13 Methods of Processing

In 1841 a very important patent was filed by a certain Stephan—later he becomes Stephen—Goldner (B.P.8873).

> A mode of heating the vessels in which animal or vegetable substances are to be preserved by driving off the atmospheric air and producing a vacuum therein, which has heretofore for the most part been performed by stoves or ovens which is liable to burn the materials. I employ a chemical bath in the manner described by John Wertheimer's Patent. I use a solution of muriate of lime or nitrate of soda, but prefer the former because I am enabled to obtain a constant temperature of 270°–280° F. without much evaporation.

The patent of John Wertheimer to which Goldner refers bears the next serial number (B.P. 8874) and from the fact that both patentees give the same address it is clear that the two men were in close association. Wertheimer, in addition to the calcium chloride bath, describes a method of closing the aperture of the tins whilst the heating is in progress.

> I am aware that the driving off air from cases by heat has been done before in preserving vegetable and animal matters in cases, but in such cases it has been thought absolutely necessary to

*Ency. Brit., 7th edn., 1841, Vol. 9, p. 732.

remove the case from the heat and allow the contents to cool before soldering up the opening; now it is peculiar to this process and most important that the opening should be closed, in opposition to the pressure within the case, caused by the heat; by such means vacuum is ensured. In the former process they could not obtain a vacuum owing to the cooling down before soldering up the orifice. In this invention, the heat is continued during the driving off of the air, also when soldering up the opening and for some time after soldering, thus avoiding that process of cooling hitherto considered necessary.

His patent shows a diagram of a little gas ring which he placed round the vents during the actual closing.

There is a great deal in these two patents which corresponds closely with the details given in a French patent taken out in 1839 (No. 11,613) by Louis Amedée Fastier. Fastier's patent says that the distinctive feature of his cans is an orifice which can be closed by a perforated capsule which can be sealed later by solder at a certain stage of the process and a plate shows 11 different forms of the filler hole. None of these filler holes differs in principle from that found by us on the veal and the carrot cans supplied by Gamble in 1824, 15 years before Fastier's patent, and credit must therefore be given to Gamble and his associates for that device. No details of the processing method employed by Gamble in the early days have come to hand and there is no evidence that he had anticipated the calcium chloride bath which forms the second claim in Fastier's patent. On the other hand, Donkin had patented a method of drying materials by means of superheated steam and he may have used some form of autoclave for processing canned foods; the remarkably low proportion of defective tins packed by his firm suggests that the method used was more dependable than Appert's original method of standing the cans in boiling water. Mr. W. Hogarth stated in his evidence before the Royal Commission in 1852 that he had invented his own process in 1837 by which high pressure steam was used.

We have not been able to trace how Fastier and Goldner were related, but it is interesting that in a brochure describing the Goldner process, published in 1843, the writer—one suspects it was Goldner or one of his associates—admits that it is based on "Le systeme Fastier." This brochure contains most laudatory testimonials from Graham and Daniell, who

at that time were the Professors of Chemistry at the two new London colleges, University and King's, respectively. It also contains the statement that Faraday opened a "box" of boiled beef and carrots at one of his lectures before the Royal Institution and demonstrated the perfect condition of the contents.

¶ 14 Goldner's Rushed Contract of 1845

Goldner was not long in getting himself accepted as a contractor for the Admiralty. In 1845 he obtained an order for tinned food for Franklin's expedition in H.M.S. *Erebus* and *Terror*. He was to supply approximately 22,000 pints of soup, 5,500 lb. of vegetables, and 31,000 lb. of meat.

On May 5 the Superintendent at the Victualling Yard, Deptford, reported to his Board that Goldner had supplied only one-tenth of this quantity and on May 8 Goldner promised that all the meat would be there by May 12 and the soups by May 15, but requested that he might be allowed to supply the soups in canisters larger than specified. Permission was granted by the Board.

In November Goldner asked that if there were any reports on the preserved meats recently supplied by him he would like to have copies, but he was verbally informed that this was not possible. Actually, things had gone very badly, for a lot of the food decomposed; no less than 15,420 lb. being condemned as unfit for consumption. Years later, when Captain Ommanney discovered on Beechey Island the stacks of provisions which the ill-fated Franklin had abandoned he reported that the canisters contained rotten meat. He indignantly asserted that they had been filled with "putrid abomination . . . thus fatally diminishing the three years' provisions which were supposed to be on board."

In 1847 preserved beef in tins became part of the general ration of H.M. ships and a considerable part of the contracts were supplied from the factories which Goldner had set up in Houndsditch and in Galatz (Moldavia, Rumania). At the time Goldner was offering a considerable range of foods: milk at 1*s*. 3*d*. a quart, soups at about 2*s*. 2*d*., real turtle at 10*s*. 6*d*., carrots 2*s*. 2*d*., soup and boulli 8*d*. a lb., and ox tongues 6*s*. 6*d*. A footnote to his price list states that the meats

could be supplied in canisters containing from 1 lb. to 500 lb. each.

It is possible that Goldner's foods prepared for *Erebus* and *Terror* went bad because their preparation was rushed, he being behindhand with his contracts, but it is also very important that it was about this time that "packs" larger than 2–6 lb. began to be prepared. About 1849 serious reports of faulty tins and bad meat were coming in from many of H.M. Victualling Yards. In 1850 the Royal William Yard condemned no less than 111,108 lb. of Goldner's meat. He and his goods came under the gravest suspicion and there were many allegations that putrid and unwholesome flesh was being canned at the Rumanian factory.

In February, 1850, his partner, Samuel Ritchie, wrote as follows:—

Sir,

Understanding that the Lords Commissioners of the Admiralty have applied to other houses for the terms upon which they will supply the preserved provisions required for the use of the expedition proceeding to the Arctic regions, I take the liberty of once more entreating their Lordships to be allowed to compete with them for the supply of the whole or a portion of the order—that an opportunity may be afforded me of wiping off the disgrace under which I at present labour, the result of a combination of the most unfortuitous circumstances against me—I have had the honour of supplying the Navy for the last ten years and not until the last few months have any material complaints been urged against my goods. This, I confidently hope, will be a sufficient excuse for thus imploring one more trial before I am entirely cut off.

The greatest possible care shall be taken in the preparation of the articles and my factory shall be open at all times for the inspection of any persons their Lordships may appoint during the progress of the work.

p. pro S. GOLDNER,
SAMUEL RITCHIE.

In a bold hand the Commissioner wrote upon this the one word "Decline."

¶15 A Royal Commission's Findings

Matters went from bad to worse. Meat was being condemned in large quantities on every hand until the storm of protests led to the appointment of a Government Select Committee to enquire into the trouble. The committee received a very large amount of evidence from which they reached the conclusion that the chief cause of canned meat going bad was a failure to ensure the complete expulsion of air from the canister and adequate cooking of the contents. They traced a correlation between the introduction of large "packs," 9-32 lb., in the contracts of late 1849 and 1850, and the sudden increase in the number of condemnations. Very few cases of putrefaction in 6-lb. or smaller canisters occurred and the committee was led to recommend that in future this should be the largest size of "pack." Goldner, in his evidence, laid stress on the great difficulty of expelling the atmospheric air from the meat itself, for he believed that the fibres enclosed it.*

It is, of course, abundantly clear that Goldner's treatment did not sterilize the centre of the larger containers. This view is supported by a conversation we have had with Mr. Thomas J. Underhill, who for many years was Senior Technical Examining Officer for the Admiralty; it was one of the outcomes of the 1852 Report that the Admiralty set up its own canning factory at Deptford. Mr. Underhill has told us that in the early days of his service at the Royal Victualling Yard at Deptford he was informed by those who had inspected Goldner's meat at the time of the great scandal in 1852 that the meat in the large tins was not adequately cooked in the centre.

¶16 Tinned Foods at the Great Exhibition of 1851

From an interesting extract from the Official Catalogue of the 1851 Exhibition we learn that the original manufacturers, now under the name of John Gamble, were then also using a "saline bath" to obtain higher temperatures. Gamble's firm exhibited canisters which had been prepared in 1813 and one which had been brought back from the *Fury's* dump (1825) by Sir John Ross in 1833. The description of the exhibit

*Report on Preserved Meat (Navy), 1852.

written by W. D. L. R. (W. de la Rue, F.R.S.) gives us a good picture of Gamble's method:

> The process consists in placing the partially cooked provisions into tin canisters, with a little bouillon or juice of the meat, then soldering on the covers, which have a small hole perforated therein. The tins are after this immersed to a great portion of their depth in a saline bath heated above the boiling point of water, and left therein until the air has been expelled as completely as possible by the steam generated within them; the hole in the cover is now hermetically closed with a little solder, the tin being momentarily touched with a damp sponge to stop the egress of steam. The minute portion of oxygen still remaining in the tins enters into combination with the animal or vegetable matter at the induced temperature and thus further change is prevented. After sealing of the tins, they are submitted to the ordeal of the testing room, heated to a temperature above 100°F.; if putrefaction takes place, the generated gases burst the tins, but those which pass uninjured remain perfectly good.

Ritchie, agent for Goldner, and McCall also exhibited preserved meats, "produce of Moldavia, preserved at Galatz, under Goldner's Patent."

For one of the expeditions which set out to find Franklin preserved foods were supplied by three firms, Gamble (tins painted blue), Cooper and Aves (painted white), and by Hogarth of Aberdeen (painted red). This was the expedition commanded by the Sir Edward Belcher, whose incompetence nearly brought disaster. The commanders of H.M.S. *North Star* and *Assistance* wrote very highly of Hogarth's preparations and seem to have considered them better than those supplied by the other firms. A tin of Hogarth's beef from this expedition of 1852 has been examined by us, thanks to the kind co-operation of the Trustees of the National Maritime Museum at Greenwich.

¶ 17 Navy's Dislike of Dried Vegetables

The list of stores taken on this expedition includes dried carrots and dried potatoes. The former were supplied by Devaux & Co. of London, and it is stated that they were prepared by Masson's method. The patent of Etienne Masson,

dated November 12, 1850 (No. 13,338), describes the drying of vegetables at temperatures between 75° and 145° F. by placing them on wicker, canvas, or open-work trays in a current of hot dry air with or without (*a*) mechanical ventilation, (*b*) lime or calcium chloride, (*c*) a vacuum. The time recommended was 20–30 hours and higher temperatures were objected to as likely to injure flavour. The partially or nearly dried products were then compressed into cakes, sometimes provided with grooves so that they could be broken up into portions for rations. The cakes, wrapped in tin foil, were packed in air-tight cases of tin or zinc. Some of the dried potatoes taken were prepared by Devaux, but another consignment was made by Edwards who took out a patent in 1840 (B.P. 8597). Edwards' product was made by pressing the boiled potatoes through small holes in the side of a tinned iron cylinder and drying the "threads" on tinned iron tables heated from below, at first to 160° F. and gradually falling to about 100° F. The dried vegetables were not, on the whole, popular. "The carrots require too much attention and therefore are not fit for sea service as rations" was one report, whilst another said that "the seamen did not take to the potatoes."

¶ 18 Prevention of Scurvy

It must be remembered that the Naval authorities looked favourably upon the preserved foods for two reasons. In the first place, they were regarded as providing a welcome relief from the monotonous ration of salt meat and hard biscuit which for centuries has been the seaman's staple fare, and, secondly, it was thought that they would provide protection against scurvy. In the early 19th century it was recognised that the disease could be both prevented and cured by fresh foods, but there lingered the belief that it was caused primarily by long-continued subsistence on salted meat. When the first preparations of tinned meats and vegetables were issued to the Navy they were welcomed as antiscorbutics, there being little differentiation between them and no suspicion that the protective value of the fresh materials might suffer during the canning process. The freedom of the Arctic expeditions of Parry and Ross from scurvy greatly enhanced the reputation

of the tinned foods as antiscorbutics, but it must be remembered that very large quantities of other protective foods were also taken. On his second voyage Parry took 6,000 gallons of lemon juice, 30 jars of sliced lemons, 200 gallons of cranberries, 300 gallons each of pickled cabbage and onions, and 5 tons of potatoes; in addition, he took 150 pots of "Essence of Spruce," which from the time of Lind had had a reputation as an antiscorbutic. We do not know how this lemon juice had been preserved, but it is clear from a note of Parry's concerning the victualling of the next voyage that it kept quite well.

> The quantity of this article I have increased very considerably —it is of the utmost importance that fresh lemons should be squeezed and that it should be prepared in the same manner as before. The lemon juice returned from the last voyage was good and might be again supplied, but it should be particularly marked to be first used.

One contemporary method used to preserve it was to add one-tenth part of brandy, sometimes after boiling, and to cover the surface with a layer of olive oil in order to exclude air.

¶ 19 Dried Vegetables for Crimean Troops

It is quite clear from writings at this time that it was not generally appreciated that the antiscorbutic potency of fruits and vegetables is impaired by drying. This is probably why supplies of dried vegetables were sent out to the Crimea at the time when our men were being ravaged by the disease. Lord Raglan, who made great efforts to improve the dreadful rations upon which our troops were expected to exist by the authorities at home, tried at one period to obtain supplies of fresh garden produce from Varna, but it proved impracticable. In response to urgent requests, the Government sent out supplies of lime-juice and preserved vegetables, but most of the cases remained in store at Balaclava and did not reach the suffering troops. The soldiers who received the dried potatoes, which seem to have been prepared by Edwards' process, disliked them heartily. Four tins of dried foods, three of carrots and one of meat powder, which were prepared for use during

the Crimean War came into our possession through the kindness of a donor, with whom we have lost touch through an unfortunate oversight on the part of one of us (J.C.D.). We wish to express our indebtedness to him. How these materials were made we do not know. The tin of meat powder bears a label with the name of Savory & Moore, but we are informed by that firm that they did not manufacture such materials at that time, but merely acted as contractors for the War Office. It is possible that the carrots were made either by Edwards' process or by a firm, such as Devaux, employing Masson's method.

¶20 Some Later Developments

Developments in the canning industry were rapid in the second half of the 19th century. The Australian industry began in 1848 with the opening of a factory at Newcastle, N.S.W., by Henry and William Dangar, and the American meat factories at Chicago and elsewhere began to operate about 1868. We have been able to examine a tin of tripe which came into the possession of the International Tin Research and Development Council about four years ago and was prepared by Messrs. Libby, McNeill & Libby of Chicago about 1880.

The old idea that one must exclude air or oxygen in order to preserve foods lived on for quite a time after Pasteur's classic researches on the rôle of micro-organisms. All the patents for this period stress the importance of expelling the oxygen from the can. As late as 1867 at a discussion at the Royal Society of Arts it was considered that the part played by organisms could not be ignored, but that the real problem was the total exclusion of oxygen, which Gay-Lussac had first suggested was the cause of putrefaction when air was present.

One method of preserving meat proposed at that time was to dip it in a solution of aluminium acetate and then in a sort of varnish of albuminous material, which was supposed to provide an air-impervious covering when dried. This recalls the earlier patents of Ludwig Granholme (B.P. 4150, 1817 A.D.) and Bouet and Douein (B.P. 2800, 1855 A.D.), which describe

the coating of meats with jelly, collodion, or other material supposedly impervious to air.

Prof. Gamgee actually proposed that beasts should be killed by suffocation in an atmosphere of carbon dioxide so that their blood might become changed into a self-preservative solution and by merely washing the carcases on the outside with sulphurous acid they would be preserved indefinitely. It was not until 1895 that bacteriology was directly applied to the problems of food canning when Prescott and Underwood in America carried out investigations upon the spoilage of canned corn.

¶21 Additional Note: Canned Beef 87 years old

Since writing the above, we have been informed by Mr. F. Huntly Woodcock, of British Canners, Ltd., that he has traced two cans which were left by Parry on the ice when *Fury* was lost. They were brought back unopened to England by Ross. They found their way into the Museum of Fisheries and Shipping at Pickering Park, Hull, in all probability because it was a Hull whaler, *Isabella*, which picked up Ross and his party in an exhausted condition in their open boat in 1833.

One canister contained pea-soup and the other beef. Apparently they were both opened about 20 years ago,* when the contents were found in excellent condition. It is reported that a meal was made of them without ill-effects. A small portion of both soup and meat were preserved in formalin and are now shown in the museum, together with the tins. They are certainly of Donkin and Hall's manufacture. We are very grateful to Mr. Woodcock for bringing this interesting information to our attention.

*In 1911, the cans being then 87 years old.

PART II

CHEMICAL INVESTIGATIONS

By PROF. J. C. DRUMMOND, D.SC., F.I.C., *and* T. MACARA, F.I.C.

¶22 Cake of Portable Soup, *c.* 1771

The cake was a flat, rectangular slab, 110 by 95 by 7 mm. and greyish white in colour. It was stamped with a "broad-arrow." At some time it had broken into two portions by a diagonal crack. Its appearance is as shown opposite; the edges of the crack had an appearance similar to those of a slab of glue; indeed, the general resemblance to glue was very striking, which is of interest in view of the contemporary description of its preparation (¶5).

A few milligrams of scrapings from an edge of the break were taken. The material was very hard and tended to fracture conchoidally just as a slab of hard glue would do. The flakes were quite transparent and a golden brown in colour. The material was readily soluble in cold water, forming a clear, pale yellow solution with only a very slight trace of flocculent insoluble matter. The reaction was acid, p_H 5·7. It was almost devoid of smell and taste. The analysis gave the following figures:

	%
Moisture	7·94
Nitrogen	14·48
N. precipitable by trichloracetic acid	3·73
Protein (3·73 × 6·25)	23·31
"Extractive" nitrogen	10·65
Total creatinine	0·79
Ash	4·0
NaCl	2·1

The analyses are entirely in keeping with what is known of the preparation of the 18th century "portable" soup. The material seems to be a desiccated clear broth, which in all probability was prepared from meat and bones. It does not appear to have undergone any marked change during 160 odd years.

Cake of portable soup

¶ 23 Parry's Tin of Roasted Veal, *c.* 1824

The general appearance of the can is shown on page 8. It bears the original label giving instructions to "cut round on the top near to the outer edge with a chisel and hammer."

On perforating the can, the rush of gases was so great that it was not possible to measure the pressure. It was probably greater than 15 lb. to the sq. in. A sample of the gases was analysed.

	%
Hydrogen	85·5
Carbon dioxide	7·2
Oxygen	0·2
Nitrogen (by difference)	7·1

On turning out the contents of the tin, we found several pieces of cooked meat, somewhat over $3\frac{1}{2}$ lb. in all, and

a fair amount of thin milky fluid. The most striking feature was the bright pink colour of the meat, resembling that of salmon flesh. The colour rapidly changed to the characteristic pale brownish-grey of cooked meat on exposure to air. The pigment was characterized spectroscopically as hæmochromogen, which rapidly forms parahæmatin on oxidation. The rather unexpected observation was made, however, on resterilizing some of the meat for preservation as an exhibit, that the pink colour returned. As this does not occur normally on withdrawal of oxygen it seems probable that a reducing system in the meat or juice effected the reversal; the agent may well have been glutathione, strong colour tests for which were given by the material. Microscopic examination showed that the juice contained fat-droplets, a considerable amount of small fragments of meat, and grains of starch. Sufficient of the latter was present to suggest either that the meat had been dusted over with flour before placing in the tin or that a thin sauce containing flour had been poured in on top of the meat.

The meat itself was in what one could fairly call "perfect" condition, the appearance of the larger fragments being quite like recently-cooked veal. There was a fair amount of white and rather slimy fatty material where the belts of connective tissue ran. This was dissected out, dehydrated by grinding with anhydrous sodium sulphate and extracted with ether.

The following table compares the analytical data for this fat with those for fat extracted from the fatty tissue of a fresh cut of veal.

	Parry's veal fat	*Fresh veal fat*
Iodine No.	54	48
Saponification value	191	194·5
Free fatty acids %	80·7	0·45
Unsaponifiable	1·02	0·85
Refractive Index 50°	1·4472	1·4520
Colour reaction with $SbCl_3$ (on unsap.)	Negative	Negative
Vitamin D, I.U. per gm.	0·6	1·0

The only surprising result is the survival of vitamin D. The hydrolysis of a large proportion of the glycerides in the tinned veal fat is what would be expected. There was no trace

of rancidity as detectable by a sensitive modification of the Kreis test. Doubtless this is due to the anærobic conditions under which the content of the tin had been preserved. The absence of vitamin A and carotene is not surprising in view of the negative tests with fresh veal fat.

The "gravy" had an acid reaction, p_H 5·5, and contained ·918 mg. per cent of lactic acid. Long standing at this acid reaction had not completely changed the creatine to creatinine; preformed creatinine 18 mg. per cent, total creatinine 36 mg. per cent. It had not, however, appreciably raised the proportion of soluble *N* not precipitable by trichloracetic acid. In extracts of fresh cooked veal this is usually about 83 per cent; in the case under examination it was 81 per cent.

The combined meat and juice were examined for vitamin B and flavin, through the kind co-operation of Dr. A. Z. Baker and Dr. M. Pyke, of Research Department, Vitamins, Ltd. The former test was negative, but flavin equivalent to 0·88γ per g. was estimated.

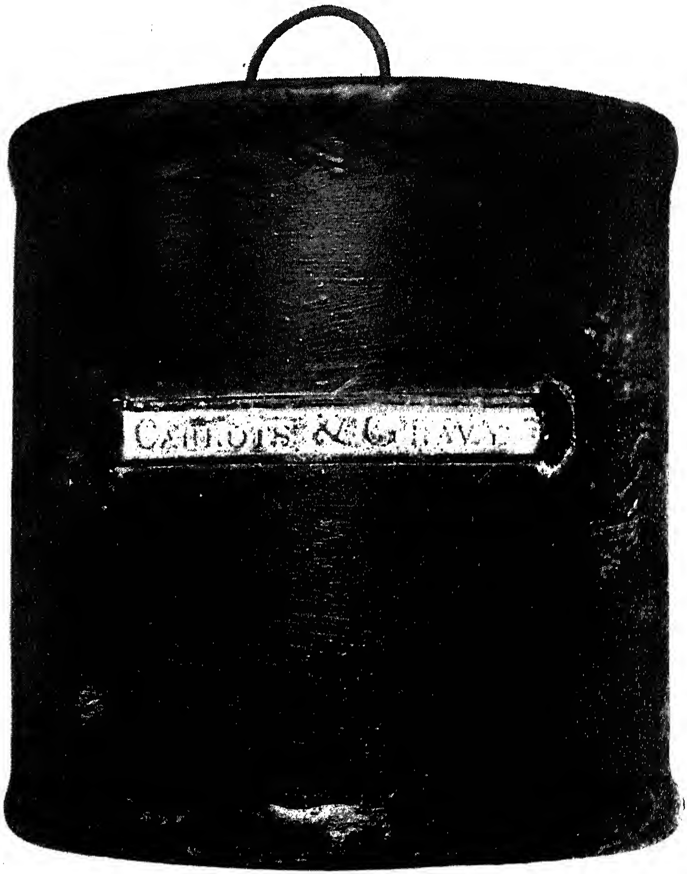
The solution of metals caused by long storage at the acid reaction of p_H 5·5, which also caused the high pressure of hydrogen, was also studied.

	P.p.m.
Iron	71
Lead	3
Tin	783
Zinc	27

The high proportion of tin is not surprising, but the amount of lead is smaller than might have been expected. The zinc was probably derived from the solder used for the seams and vent-hole (see Part IV).

The material was also examined for certain preservatives, although there was nothing in the early references to Donkin's process which led us to suspect that any of them had been used. None was found.

	%
Salt	0·14
Nitrates	nil
Nitrites	nil
Boric acid	nil
Phosphates	0·46



Can of carrots from Parry's 1824 *expedition*

A mixed sample of the meat and juice was given to 12 young adult rats for 10 days. They ate the supplement of 5 g. daily with avidity without any obvious harmful effect. The average increase in growth over the period was 15 g.; well within the normal range. An adult cat was given a single meal of 75 g. of the meat and gravy without any ill-effects.

¶ 24 Parry's Tin of Carrots and Gravy, *c.* 1824

The tin, showing the stamped metal label, is shown opposite.

On punching the tin a positive pressure of about 15 lb. per sq. in. was measured, but unfortunately, owing to the surface of the end of the can being not quite uniform, the gasket did not effect an entirely satisfactory seal.

Analysis of a sample of the gases gave:

	%
Hydrogen	79·5
Carbon dioxide	15·3
Oxygen	0·4
Nitrogen (by difference)	4·8

There was an unusually large headspace in the tin, and it was clear on removing the contents that they had been packed without much liquid. No evidence was obtained of gravy having been used in the preparation of the pack, as the label indicated. This was confirmed by a negative response to tests on the juice for creatinine. From this and the general appearance of the contents, which weighed just about 2 lb., it seems clear that the tin had originally been filled with slices of carrots, which, on cooking, had shrunk to produce a relatively large headspace and to exude a certain amount of juice. The appearance of the carrots immediately on opening the tin was almost that of freshly cooked carrots which had been allowed to become cold. The bright orange colour seen at the first moment changed in a few minutes to a rather dull orange with a slight brownish tint which remained permanent. On re-sealing a sample in glass and sterilizing, the bright orange colour did not return as did the pink colour of the roast veal. It seems likely that the change was due to oxidation of phenolic substances on contact with the atmosphere and that the resulting brownish pigments dulled the orange colour of the natural colouring. The contents of the freshly opened tin smelt sweet and just like freshly cooked carrots, except that there was definitely a suggestion of something "metallic" in the smell. To the tongue the taste was both sweet and "metallic." The contents contained 83·34 per cent of moisture, which supports the view that gravy was not added.

By high pressure the material was separated into a fraction of juice and a "press-cake"; 390 g. yielding 230 g. of juice and 160 g. of "cake." The juice was acid, p_H 4·5, dark brown in colour and rich in reducing sugars. Mr. W. A. Davis, of the Research Department, Great Burgh, Epsom, very kindly estimated sugars for us.

	%
Reducing sugars (as invert) ..	5·96 w/w.
Saccharose	0·18
Total sugars	6·14
Total sugars (as invert)	6·15

The greater part of the saccharose had, therefore, become inverted by long standing at p_H 4·7. Ether extraction of the juice did not remove any lipochrome pigments, all of which remained behind in the "press-cake."

We had hoped to be able to determine whether the fluid expressed from the carrots still contained ascorbic acid, there being a possibility of this in view of the acid reaction and the anærobic conditions under which the food had been so long preserved. Unfortunately, there was scarcely sufficient material for one animal test, so that was not undertaken. Attempts to estimate ascorbic acid by the usual titration method failed, because of interference by the large amount of pigment, and, more serious still, the heavy contamination with dissolved tin. We are greatly indebted to Miss M. Olliver, of Messrs. Chivers' Laboratories, for assistance with this part of the work.

The "press-cake" was dried by grinding with anhydrous sodium sulphate and repeatedly extracted with ether. The extract was deep golden-orange in colour. The pigment was entirely epi-phasic, between light petrol and 85 per cent methyl alcohol, indicating that the xanthophyll type of pigment was absent. The light petrol fraction showed, on spectroscopic examination, clearly marked bands with maxima at 456 and 486·5 mμ, and the suggestion of a band with a maximum about 520 mμ. It appears, therefore, to be unchanged β-carotene.

The amount of carotene, estimated colorimetrically, corresponded to 6·4 mg. per cent of the original contents of the

Can from Belcher's expedition of 1852

tin, a figure indicating that the carotene content of the original carrots had been little affected by the canning and long storage. In this connection it must again be borne in mind that an atmosphere of hydrogen prevailed in the tin for the greater part of the period.

Examination for metals showed that a very large amount of tin, equivalent to 17 grains per lb., *i.e.*, 8·5 times the permissible amount for edible products to-day, had gone into solution.

	P.p.m.
Tin	2440
Iron	308
Copper	5
Zinc	4
Lead	nil

¶25 Tin of Roast Beef, Belcher's Expedition, 1852

The can is shown on page 41. Dents caused by rough handling are clearly seen. Before the tin was opened a small pin-hole was detected which had obviously formed a considerable time ago and had become occluded by corrosion and by the solidification of exudate. In view of this, no attempt was made to measure the pressure in the tin or to withdraw a sample of the gas. It was also useless to attempt a bacteriological examination. On opening the tin a solid "pack" of coarse-fibred beef, rather resembling "bully" beef, was found. One side in contact with the tin, and corresponding with the pin-hole which had been noticed, had some considerable time before become contaminated and partly decomposed. The remainder of the meat was not in too bad a condition, although rather blackened in parts. It showed a pinkish tint which tended to darken on exposure to air, but the colour was not so striking as in the case of the veal sample A. It was not thought worth while examining the meat, but a sample of fat taken from the portion least affected by the contamination was separated and analysed. As was expected, most of the glycerides had been split.

	%
Free fatty acids	76·0
Unsaponifiable	0·56

The unsaponifiable was coloured pale yellow and showed, much to our surprise, a faint slate-blue coloration with $SbCl_3$, indicating carotinoid pigments. The phase test showed that a pigment of the carotene type was present and a colorimetric assay indicated 0·18 mg. per cent expressed as carotene. The survival of this pigment, which is a normal constituent of "grass-fed" beef fat, is interesting and suggests that in spite of the defect in the tin that part of the contents remote from the leak had been kept in an anærobic atmosphere.

¶26 Libby's Tinned Tripe, *c.* 1880

The general appearance of the tin is shown opposite. From the type of "pack" and information on the label of the tin it is surmised that it was prepared about 1880. The tin appeared to be in sound condition. The pressure registered was 650 mm.

LIBBY'S TINNED TRIPE, *c.* 1880

Tin of tripe about 1880

(atmospheric, 767 mm.) corresponding to a partial vacuum of 117 mm. The gaseous mixture was mainly nitrogen.

Hydrogen	13·6 %
Carbon dioxide	2·5
Oxygen	0·3
Nitrogen (by difference)	83·6

Three canisters of dried vegetables (left) and of dried meat powder (right) packed for the Crimean War—1855

This analysis is very much what would be expected. The oxygen of the original air had been almost wholly absorbed by combination whilst the hydrogen was derived from solution of metals. The acidity of a small amount of milky juice was p_H 6·4. The interior surface of the can was fairly badly attacked, a considerable amount of iron, but less tin than might have been expected, having gone into solution.

	P.p.m.
Copper	1·5
Iron	539·0
Lead	nil
Tin	163
Zinc	11

The tripe was discoloured and blackened in a few places where it was in contact with corroded parts of the tin, but otherwise appeared to be in good condition. The meat showed a bright pink colour immediately on removing from the tin. It was much less marked than in the case of the veal, but was also due to hæmochromogen. It faded on exposure to air.

In view of the "normal" appearance of the tripe, it was not thought worth while making any other analyses. It proved to be harmless when given to young rats over a period of 20 days; about 5 g. a day was eaten by each animal.

¶ 27 Dried Powdered Carrots, *c.* 1855

There were three tins, each holding about 2 kg. The covers fitted tightly but were not sealed. In view of this it was not thought worth while making a bacteriological examination.

The exterior of the tins was covered with rust but on opening it was found that the interior had been lined with paper and that this had protected it from attack. They are shown opposite. The metal surface of the interior was almost as bright as when new. The paper lining was almost intact. Two tins had not, apparently, been opened since originally prepared, the paper being still folded over the contents at the top. The third tin had been opened and a small portion of the contents removed. In this case there had been attack by a beetle, *Sitodrepa panicea.* L. (family Anobiidæ) which,

we are informed by Sir Guy Marshall, Director of the Imperial Institute of Entomology, is a common pest of all stored vegetable foods. We are greatly indebted to him for identifying this insect and also that which we found had attacked the dried meat preparation.

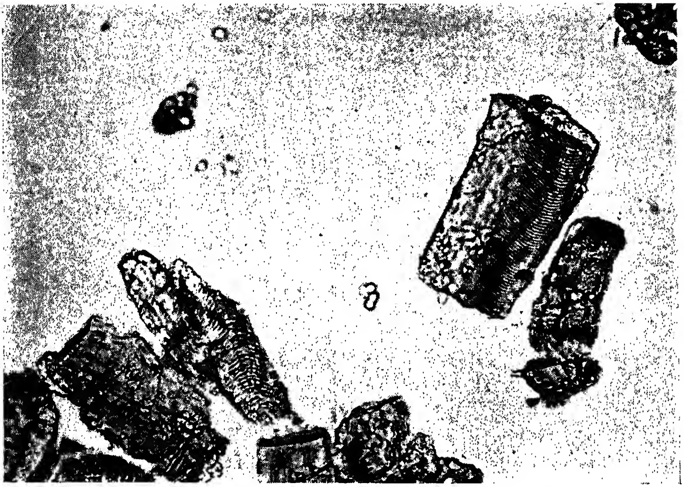
The contents of all these tins appeared very similar, a dark brown powder which had become compressed into a fairly hard mass, with a strong smell recalling spices or curry-powder. The smell did not in any way recall carrots. Analysis revealed an unexpectedly high amount of water (20 to 21 per cent) and it is, therefore, quite extraordinary that we found no trace of moulds having at any time infected the material. The analyses show that the three tins contained the same type of preparation.

	Tin 1	*Tin* 2	*Tin* 3
Moisture	20·50	20·79	21·83
Total N.	1·29	1·31	1·37
Ether extract	0·53	0·82	0·87
Ash	6·21	5·95	6·33
Fibre..	29·70	31·82	27·50

The ether extract was quite free from colour and no indication that the material had ever contained carotene was obtained. Microscopic examination of the powder revealed characteristic structures of the roots of carrots and there is no reason to think that it contained anything else. An aqueous extract showed the presence of reducing sugars and sucrose. It was very acid, p_H 4·1. Sugars were estimated for us by Mr. W. A. Davis, of Great Burgh, Epsom. For his help we are much indebted.

	in dry powder %
Reducing sugars (as invert).. ..	6·63
Saccharose	7·15
Total sugars	13·78
Total sugars (as invert)	14·15

The analytical examination suggests that apart from the inversion of some sucrose and complete oxidative destruction



Muscle fibre isolated from the dried meat

of the carotene and, possibly, other fatty constituents, the material was not greatly changed by its long storage.

¶28 Dried Meat Powder, *c.* 1855

The tin was badly rusted on the exterior and had obviously been previously opened as the cap was not properly in position. From the rusting it seemed likely that the lid had been removed a long time ago. It is shown on page 44. On opening it a strong smell of ammonia was noticed. The contents appeared, at first sight, to be in a very bad state. The whole of the upper layers had been attacked by a moth, kindly identified for us by Sir Guy Marshall as *Tinea palles centella*, Staint (family Tineidæ), which has a taste for dried meats and hides. These layers were a mass of meat residues, dead moths in various stages of development and a curious kind of web-like material which they had presumably spun. The paper with which the tin had been originally lined was almost wholly destroyed and the interior surface of the tin was badly rusted and corroded. On examining the contents more carefully it was found that at the centre was a fair amount of material

which had not been attacked by moth or mould. This material formed a hard cake of pale, sandy-coloured material which could readily be ground to a coarse granular powder. It had a strong smell of ammonia. Microscopic examination showed that it consisted of fragmented muscle tissue and it was not difficult to find fibres showing the typical cross-striations of voluntary muscle. This is shown on page 47. An aqueous extract was slightly alkaline, p_H 7·4.

Analyses gave the following data:

	%
Moisture	11·66
Nitrogen	13·69
Protein	85·56
Ash ..	2·30
Ether extract	1·02

An aqueous extract contained ammonia corresponding to 0·92 per cent in the powder. It also contained both creatine and creatinine.

Preformed creatinine	103 mg. on powder.
Total creatinine	120 ,, ,,

A test for glutathione was negative. The fat separated from a quantity of the meat powder by ether extraction was examined.

	%
Iodine number	14·5
Free fatty acids	65·4
Saponification value..	179·7
Unsaponifiable	5·8

The low iodine number as well as the high m.p. of the separated fatty acids, 46°, suggested that oxyacids had been formed by slow oxidation on the surface of the powder. This was confirmed by a determination of the acetyl value of the acids which gave the figure 20. Neither the fat nor the unsaponifiable fraction gave any reaction for carotinoids or vitamin A; it would have been very surprising if they had done so.

The very pale colour of the meat powder strongly suggests that it was veal or, less likely, chicken.

PART III

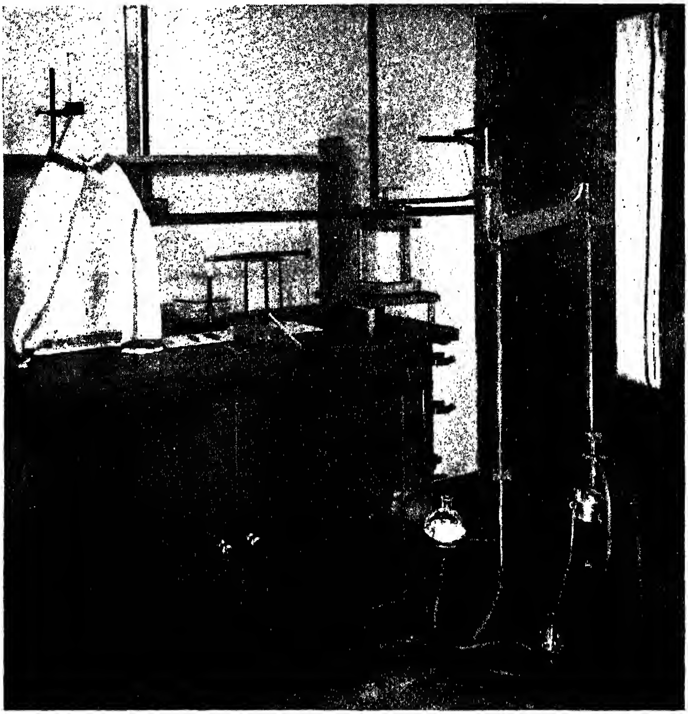
BACTERIOLOGICAL INVESTIGATIONS

By PROF. G. S. WILSON, M.D., B.S., F.R.C.P., D.P.H., *and* H. L. SHIPP, B.SC., A.I.C.

¶ 29 Technique

The windows of the room were closed for two hours previously. The bench and all apparatus were swabbed with lysol solution. The top of the tin was washed with soap and hot water, dried, and rubbed well over with absolute alcohol. This removed paint or varnish when present and exposed the metal. The surface was then cleaned with ether, and finally pure "Dettol" was rubbed over with sterile cotton wool and left for a quarter of an hour to dry. Immediately before opening the tin, the surface was flamed from below with a Bunsen and then covered with a Petri dish. The rubber gasket, which had been boiled, left overnight in 5 per cent pheno-solution, and washed in sterile water, was put in place with sterile forceps. The piercing instrument, which had been autoclaved and then exposed to hot air at 155° C. for 3½ hours, was fitted to the top and the lid was pierced. After the pressure had been measured and restored to normal the piercing instrument was removed, a sterile Petri dish cover put over the hole, and the tin moved under a large sterile funnel surrounded by a glass cloth curtain. By means of sterile Pasteur pipettes drawn out to a very fine point, samples of fluid were removed through the small hole made by the piercer and placed in sterile bottles, a separate pipette being used for each bottle. The small opening, about 1 mm. in diameter, was then enlarged by carefully hammering in a heated poker. Small pieces of the solid contents were extracted with sterile bullet forceps or glass sampling tubes and placed in sterile bottles.

All the samples of any one can were examined on the same day, some at the London School of Hygiene and Tropical Medicine (G.S.W.) and some at the Laboratories of the Food Manufacturers Research Association (H.L.S.). The strictest precautions were taken in the laboratory to avoid contamination. The windows and the door were kept closed, the bench



General view of the apparatus for opening the cans

and all apparatus were swabbed with a wet cloth, and the whole of the work was carried out under a funnel surrounded, except for an opening in the front, by a clean wet glass cloth. The hands of the operator and assistant were specially cleansed, and complete silence was maintained so as to avoid contamination by droplets expelled from the mouth.

¶30 Parry's Tin of Roasted Veal

Examination at School of Hygiene.—The soup-like fluid was removed with sterile Pasteur pipettes and distributed into a series of media in quantities of 0·1–0·2 c.c., the contents of the different bottles being kept separate. The meat was cut

into small pieces in a sterile Petri dish with sterile instruments, and distributed piece by piece into the different media. Some of the meat was then ground up in the soup-like fluid, using a sterile Griffith tube, suspended in sterile Ringer solution, and inoculated intraperitoneally into ten mice in quantities 0·1–1·0 c.c.

Microscopical examination.—One drop of the creamy fluid was spread over an area of about 1 sq. cm. on a series of slides, and stained with various stains, including Gram and Ziehl-Neelsen. Very few organisms were seen. In the Gram preparation about 6 groups were found in the whole film, comprising Gram-positive, square-ended rods about 3–4 μ by 1 μ, often arranged in short chains of two or three. No acid-fast bacilli were found in the Ziehl-Neelsen preparations.

Cultural examination.—Since very few living organisms could be expected to be present, it was felt that the only hopeful method of cultivation was to inoculate large numbers of tubes of different media and incubate them under varying conditions. Accordingly, a total of 64 tubes of broth, serum broth, blood broth, glucose broth, Hartley broth, litmus milk, glucose agar, MacConkey broth, Koser's citrate medium, and cooked meat medium, were inoculated either with the fluid or with the solid contents, and put up ærobically at 22°, 37°, and 55° C., anærobically at 22° and 37° C., and in 10 per cent CO_2 at 37° C. Glucose agar plates were inoculated directly and incubated ærobically and anærobically at 22° and 37° C. In addition, beerwort agar was inoculated and incubated ærobically at 22° C. in case any moulds should be present. The direct plates were examined during the following week. Apart from obvious contaminations from the side, they remained sterile. The cultures in fluid media were plated out after 17 and 28 days' incubation. In most instances the subcultures were incubated under the same temperature and atmospheric conditions as the parent cultures, the subcultures from cooked meat media were incubated both ærobically and anærobically. All plates remained sterile with the five following exceptions.

(1) Cooked meat medium inoculated with meat, incubated ærobically at 22° C., and plated out after 17 days.

(2) Cooked meat medium inoculated with meat, incubated ærobically at 37° C., and plated out after 17 days.

(3) Cooked meat medium inoculated with creamy fluid, incubated ærobically at 55° C., and plated out after 28 days.

(4) Litmus milk inoculated with creamy fluid and incubated ærobically at 55° C., and plated out after 28 days.

(5) Glucose broth inoculated with creamy fluid, incubated ærobically at 55° C., and plated out after 28 days.

Mouse inoculation.—Three of the inoculated mice died after 1, 3, and 3 days respectively. No characteristic lesions were found at post mortem, and spleen cultures yielded only coliform bacilli, such as are common in mice that have been dead for some hours. The remaining seven mice were killed after 14 days. The spleen of each mouse was dropped into a tube of broth; this was incubated at 37° C., and plated out after 3 days. All cultures remained sterile, except for one, from which a pure culture of an ærobic spore-bearing bacillus was obtained. This was labelled strain 6.

Characters of the Six Strains Isolated.—The five strains isolated by direct culture and the one strain isolated by animal inoculation were purified by three successive platings before being studied. Space does not permit of a detailed description of these organisms. Suffice it to say that all strains belonged to the ærobic spore-bearing group. They were motile, formed sub-terminal ovoid spores, measured 2–3 $\mu \times 0{\cdot}7$–$1{\cdot}0$ μ, and were Gram-positive in young culture. They grew readily on ordinary media, but strains 3, 4, and 5 failed to develop in the presence of bile salt. Though growth was best at 37° C., all strains grew quite well at 55° C., and some strains to a small extent at 60° C. In cooked meat medium cultures they resisted boiling for about 1–3 hours, but none survived for 6 hours. Comparison showed that strains 2 and 6 were probably identical and that strains 3, 4, and 5 were probably identical. That is, three different types of ærobic spore-bearing organisms were isolated. In view of their historic interest the strains have been deposited with the National Collection of Type Cultures at the Lister Institute.

Examination at Food Research Laboratories.—Essentially the same technique was employed as at the School of Hygiene, but the examinations were rather less extensive. No mouse inoculations were made. In the microscopical examination a few Gram-negative bacilli were seen. Forty cultures were

put up under ærobic and anærobic conditions at 22° C., 37° C., and 52° C. The media used for ærobic cultivation were Lemco broth, glucose agar, and nutrient gelatin, and for anærobic cultivation Lemco broth, glucose agar, and cooked meat medium. The cultures were examined after 10 days and again after 3–4 weeks. All remained microscopically sterile.

¶31 Parry's Tin of Carrots and Gravy

Examination at School of Hygiene.—Three samples were studied separately. The carrots were cut into small pieces in sterile Petri dishes and inoculated into a variety of media, including heart extract broth, glucose broth, MacConkey broth, cooked meat medium, and litmus milk. In all, 30 tubes were put up. The cultures were incubated ærobically at 22° C., 37° C., and 55° C., and anærobically at 37° C., and plated out after 6, 29, and 42 days. With the exception of one tube of cooked meat medium, which had been inoculated from the third specimen of carrots and proved to be contaminated with *Staph. aureus*, all tubes remained sterile.

Examination at Food Research Laboratories.—Cultures were put up from the three samples in the same way as for the roasted veal. Each sample was ground up in 12 c.c. of broth before inoculation. Altogether 30 tubes were inoculated, each with an amount corresponding to 0·1–0·2 g. of the original sample. No visible growth occurred, and the cultures were discarded after 4 weeks.

¶32 Libby's Can of Tripe

This was examined by one of us only (H.L.S.) at the Food Research Laboratories. Cultures were made from four samples of juice and meat in the same way as for the roasted veal, and examined after 1, 2, 4, and 7 weeks. Forty tubes were put up. No growth was observed.

¶33 Discussion

The main question is whether the six strains of ærobic spore-bearing bacilli isolated from the veal at the School of Hygiene were derived from the veal itself or represented contaminations from the outside. The reasons why it is believed that they came from the material in the can rather than from other sources are as follows:

(1) The greatest sterile precautions were taken in the removal of the veal from the can and in its subsequent treatment in the laboratory.

(2) Three of the positive cultures had been inoculated with the first fluid to be withdrawn from the can—the fluid in fact that was the least liable to be contaminated.

(3) The carrot cultures, which were put up under similar conditions, remained sterile except for one obvious contamination.

(4) The common contaminating organisms, such as Staphylococci, micrococci, and diphtheroids, were not found in the veal cultures.

(5) The organisms that were isolated all belonged to the ærobic spore-bearing group—a group of organisms in fact that is highly resistant to heat, and is known to survive for several years under favourable conditions.

(6) The isolation of an ærobic spore-bearer from the spleen of a normal mouse is, in our experience, a very uncommon occurrence, and suggests that the organism isolated was present in the inoculum.

(7) The organisms that were isolated resembled in general appearance the organisms seen in the direct microscopical examination of the soup.

It is a little difficult to understand why positive results should have been obtained only at the School of Hygiene and not at the Food Research Laboratories. Possible explanations for this discrepancy may be found in the fact that in the former laboratory (1) many media were used which were rich in animal protein; (2) the tubes of cooked meat medium, in which three of the strains were isolated, were incubated ærobically, whereas in the Food Research Laboratory they were all incubated anærobically; (3) no tube was discarded till plating had proved it sterile, whereas in the Food Research Laboratory the tubes were discarded on microscopic examination alone; plating is especially desirable with cooked meat media and litmus milk; (4) mouse inoculation was employed, which resulted in the isolation of one strain.

It is of particular interest to note that the six strains isolated from the veal at the School of Hygiene were all capable of growing at 55° C. The finding of such thermophilic, or poten-

tially thermophilic organisms—if the expression will be excused—in meat is very surprising. It seems probable that they were derived not from the meat itself, but from the cornflour or other starchy material used to thicken the soup in the can. Mr. L. H. G. Barton, of Messrs. Heinz & Co., who made this suggestion, kindly tells us in a personal communication that substances such as cornflour, rice flour, and arrowroot frequently have a high content of thermophilic organisms. In this connection it may be recalled that the thermophilic members of the ærobic spore-bearing group are often extremely resistant to heat, sometimes withstanding boiling for as long as 22 hours (Bigelow and Esty, 1920).[1]

The survival of living spores in the can of veal for over a hundred years may perhaps have been favoured by the strictly anærobic conditions present, which would prevent all growth and metabolism. Had growth been able to occur it seems highly probable that the organisms would have been destroyed by the high content of dissolved tin in the soup.

¶ 34 Summary and Conclusions

1. From the can of veal six strains of ærobic spore-bearing organisms were isolated, one at 22° C., one at 37° C., three at 55° C., and one by mouse inoculation. The 37° C. strain appeared to be identical with the mouse strain, and the three strains isolated at 55° C. appeared to be identical with each other. Three different types of strain were therefore isolated. All strains were capable of growing at 55° C. Reasons are given for believing that these organisms were present in the can and did not gain access to the material from outside sources. It seems probable that the strains were derived not from the meat itself, but from the starch which was used to thicken the soup.

2. Examination of the can of tripe and the can of carrots yielded completely negative results.

3. The survival of spores in the living condition for over a hundred years has, we believe, no parallel in bacteriological records.

REFERENCE

[1]Bigelow, W. D., and Esty, J. R. (1920), J. infect. Dis., 27, 602.

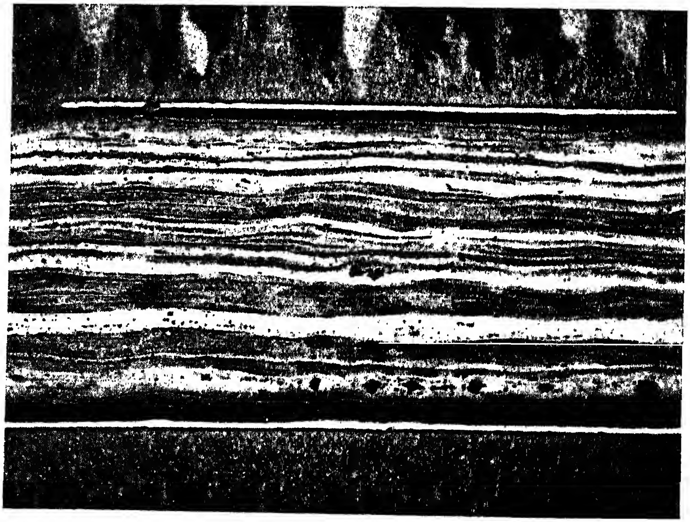
PART IV

INVESTIGATION OF THE METAL CONTAINER

By W. R. LEWIS, B.SC.

¶ 35 Qualities of Early Tinplate

The history of the containers establishes fairly closely their dates of manufacture as follows: the two cans from Parry's expedition 1824 A.D.; the beef can from Belcher's expedition 1851 A.D.; the four canisters of dried foods about 1855 A.D. They were therefore all made from sheets of tinned wrought iron and not of steel which is the basis of modern tinplate. The tinplates of that period were classed according to whether the wrought iron had been refined with charcoal or coke



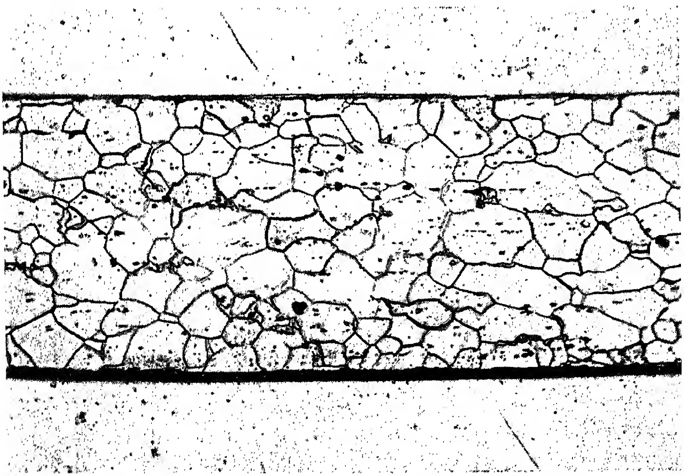
Magnified section (x 250) *through base of* 1824 *veal can showing structure typical of wrought iron*

and the terms "charcoal" and "coke" are still used to distinguish different qualities of tinplates although charcoal is no longer used in their manufacture.

The cans were made in England and the tinplate was therefore of South Wales origin, the tin being Cornish. The tripe can of 1880 A.D. was made in Chicago of tinplate which was supplied by South Wales since the United States had at that time no tinplate manufacturing industry.

¶36 Can of Veal from Parry's Expedition of 1824

A section of the tinplate cut from the bottom of the veal can has been examined by Mr. W. E. Hoare of the International Tin Research and Development Council and found to exhibit the characteristically laminated structure of wrought iron as shown opposite; for comparison a photomicrograph of a section of modern steel tinplate is shown below. The tinplate was found to be 0·0185 in. in thickness with a coating of tin of approximately 0·00051 in. in thickness on each face (Figure below). These figures correspond to tinplate of 165 lb. substance carrying a tin coating amounting to

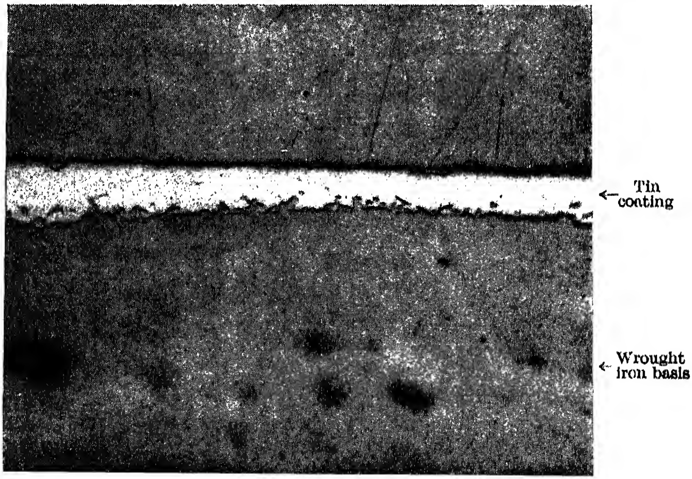


Magnified section through modern tinplate showing typical steel structure

8 lb. 11 oz. per basis box. Mr. D. M. Smith of the British Non-Ferrous Metals Research Association has kindly examined the tin spectrographically and confirms that it is of high purity, at least 99·92 per cent; this is in accord with the known use of pure Cornish "stream" tin in South Wales during the early part of last century (Figure below).

The body is made from a single piece of tinplate formed into a cylinder and having its edges folded together into a lock seam one eighth of an inch wide. Solder was floated over the inside of this seam instead of the outside as would be done to-day. It was not possible to see whether the extremities of the lock-seam were notched to convert them into lap-seams where they join the can ends because large blobs of solder had been applied over these places to make them more secure.

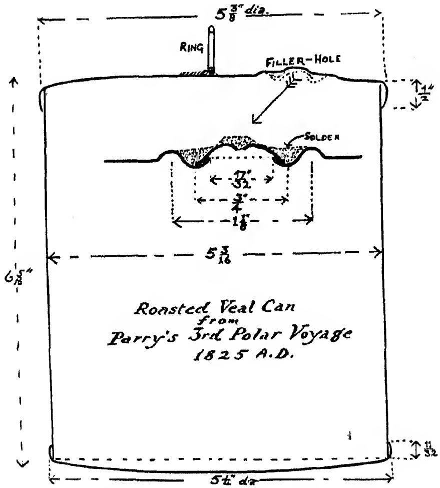
The ends were tinplate discs with a raised flange about a quarter of an inch deep fitting closely round the can body. There is no excess of solder visible on the bottom seam, which would be made in the tinsmith's shop, but the seam



Magnified section showing tin coating on wrought iron base of the veal can

of the top end, which had to be made after the solid contents had been filled into the can, was thickly coated with solder.

The top end or cover of the can has a lifting ring soldered to the centre and "17" punched on the solder at this point. The cover was fitted so that the filler hole was on the opposite side to the side seam, presumably to avoid melting the solder there later when the filler hole was capped. The design of the filler hole is shown below. To facilitate the closing, the cap and groove would have been tinned with solder beforehand but even so the heat of the soldering iron caused the solder nearby in the end seam to soften and sweat out in beads.



Construction of the 1824 *veal can*

Height, 6¼ in. Diameter, 5¼ in.

Weight, 1 lb. 1 oz.

Weight of meat and gravy, 4 lb. 8 oz. (Gamble's contract says 4 lb. of veal).

Thickness of the wrought iron tinplate, 0·0185 in.

Thickness of the tin coating, 0·00051 in.

Equivalent to tinplate of 165 lb. per basis box* with a tin content of 8 lb. 11 oz.

*The standard quantity of tinplate, equal to 31,360 sq. in.

The filler hole is well designed and made. The smoothness of the corrugations round it shows that they were formed by stamping the can end between dies, probably in a hand press.

Scratches on the inside show that the empty can and the cover were vigorously scoured with sharp sand before filling. The can was filled with the freshly roasted veal, its cover soldered on and boiling gravy poured in through the filler hole which was then covered by the cap, through the centre of which a small vent hole was pierced. After processing until steam issued from the vent hole, this would be sealed by a drop of solder and the can would be replaced in the bath until the required processing time had elapsed. After cooling, the can was painted to prevent rusting and a printed label stating the nature of the contents was later pasted over it. On the bottom end a small blob of solder, not sealing a hole, bore a punched "4," probably the nominal weight in pounds of the contents.

About half of the inside surface of the veal can was corroded in patches, the remainder being still bright or only slightly purpled. Corrosion has followed many of the scratches, but it is noteworthy that scratches on the outside are sometimes still brightly tinned although they pass through areas which are quite badly corroded (Photographs p. 62 and p. 63).

¶ 37 Parry's Can of Carrots and Gravy

Part of the can bottom was cut away with a can opener and the contents removed. The interior of the can was in excellent condition, being brightly coated with tin. The coating was feathered and a band about an inch wide near the surface level of the contents was finely etched. There was no blackening and only a trace of purpling near the top of the can. One or two minute rust spots were visible at a dent which had evidently been produced before the can was assembled.

The construction of the can resembles that of the veal can, except that the side seam is a plain lap seam instead of a lock seam. The overlap of the ends of the body blank tapers from half an inch at the top to five-eighths at the bottom; the seam has been soldered on the inside as well as the outside. The filler hole has the same kind of closure and soldered vent hole

as the veal can but lacks the two corrugations. The solder upon the ends is thickly, but not very neatly, applied. A strip of tinplate embossed with the words "Carrots and Gravy" is attached to the body by two dabs of solder. There is a lifting ring in the top, attached by solder on which is stamped "2," probably indicating the weight of the contents, but no solder on the bottom or any other figures. The can was painted, probably by the packer, with a light yellow paint, along the brush lines of which rusting has occurred in many places. A piece of writing paper with faint writing visible on it was stuck on over the paint many years ago; rusting has occurred owing to the gum and the paper has become blackened and indecipherable.

Height of can, 4⅞ in.	Diameter, 4½ in.
Weight of can, 14 oz.	
Weight of contents, 2 lb.	

This was the weight mentioned in the contracts of Gamble for the supply of carrots for this expedition.

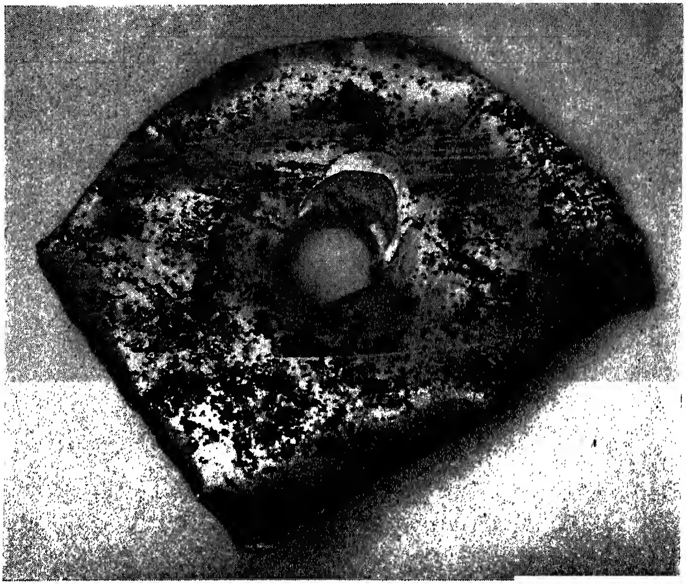
The tinplate was of the same quality as that used for the veal can.

¶38 Roast Beef from Sir Edward Belcher's Arctic Expedition of 1852

This can had been recovered from a dump of stores discovered by Captain Leopold McClintock, R.N., in 1859 and deposited in the National Maritime Museum at Greenwich. It was painted red and stencilled in black with the words "Roast Beef." All that part of the meat that had been in contact with the can was thickly coated with black corrosion products of the tin and iron, the result of the can having been perforated for many years.

Construction.—Embossed in a circle on the bottom was the name "D. Hogarth & Co.", a firm whose factory was at Aberdeen.

The body is made from two pieces of tinplate each 9½ by 5½ in., soldered into a cylinder along their shorter edges. The can ends are provided with flanges a quarter of an inch deep which fit closely to the body. All the seams are of the

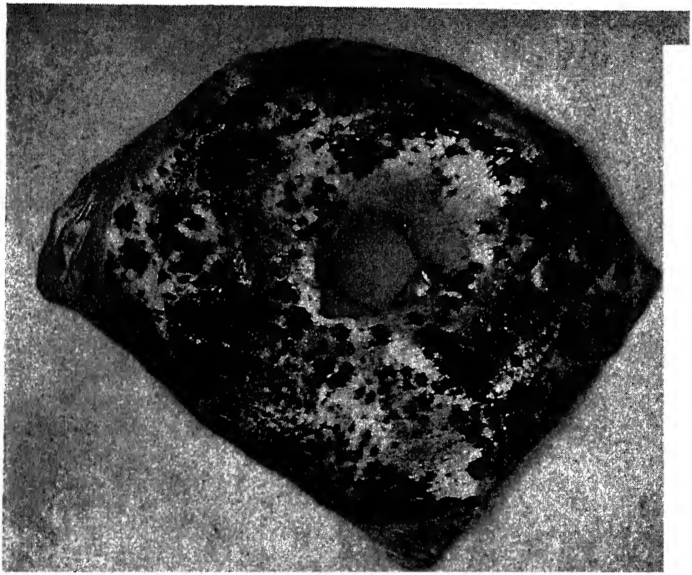


Exterior surface of a portion cut from veal can (actual size)

plain lap type neatly soldered without any excess. At the junction of the side seams with the can ends reinforcing blobs of solder have been applied. The meat was filled as a solid pack without gravy and there was no filler hole in consequence. The vent hole is in the middle of the lid and has been closed by a bead of solder applied from a soldering bit over a spot that had been tinned beforehand. A short strip of tinplate was secured at one end by solder under this spot inside the can so as to keep the meat from choking the vent hole.

Height, 5½ in. Diameter, 5⅝ in.
Weight, 14 oz.
Weight of contents, 4 lb.

The thickness of the tinplate averaged 0·0135 in., equivalent to 118 lb. per basis box, with a tin yield of 8 lb. per basis box.



Interior surface of a portion cut from veal can

¶39 Tin of Tripe

This can bears the label of Messrs. Libby, McNeill & Libby of Chicago. It came into the possession of the International Tin Research and Development Council about four years ago after a grocer had written to the newspapers recording that he had just come across two such tins among some old stock and had consumed the contents of one can without ill effects. Its age is not known precisely but the makers were able to confirm that the label was in use about 1880 for a short time.

Construction.—The can is accurately and neatly made. It is $4\frac{19}{32}$ in. high and $4\frac{9}{32}$ in. in diameter. The ends overlap the body to a depth of $\frac{3}{32}$ in.; the side seam is a plain lap soldered seam with a $\frac{3}{8}$-in. lap.

The two ends are just slipped over the body ends and

soldered. The bottom end is a single piece of tinplate, cut out and stamped in one operation. The top end is made up of a central disc about 3¼ in. diameter soldered to a ring of tinplate which was slipped over and soldered to the body of the can. Both the bottom and this ring have been exceptionally thickly coated by dipping in pure tin so that they could then be easily and rapidly attached to the body by touching them with flux and applying heat and pressure with the heavy circular "capping iron" which was then in use. This is confirmed by the absence of any traces of solder on the outside of the end seams, for a smear of solder is always left round the outside of the can by the later method of rolling the assembled can over molten solder in a bath; moreover, this method was not introduced much before 1887. This method of attaching the can ends by sweating had the advantages of providing a smooth continuous surface of tin inside the can and there is no corrosion or pitting at the seams.

After the bottom and the open ring for the top had been sweated on the can would be washed and filled. Two half-circles of white paper were then slipped in above the meat. The 3¼-in. closure disc, numbered 10 for purposes of checking the packing, was placed over the ring and sweated on by a hot capping iron. A hole was then punched in the centre of the lid to allow air and steam to escape during the first processing, and later, while the can was hot, closed with a blob of solder. The paper circles prevented the contents from choking the vent hole and also prevented contact with solder. After sealing, the can would be given a prolonged cooking to sterilise its contents.

The exterior of the can is in good condition although slightly dented at one or two places on the sides. The ends were both concave indicating a pressure considerably less than atmospheric inside. As protection against rust the two ends had been dipped in a blue lacquer before the label was applied. The label is almost entire and little the worse for wear or rust spots; it is printed in black, red, yellow, and blue with a varnished finish. It describes the contents simply as "Choice Tripe—The Best" and gives directions for warming before use.

¶ 40 Canisters of Dried Vegetables and Meat

As these were made for the Crimean War they are not more recent than 1855. Three contained dried carrots and were still brightly tinned over almost the entire inside surface; the fourth, containing dried meat, had corroded so much that scarcely any tin remained on the inside. The exteriors had not been protected in any way and were tarnished and flecked with rust spots.

The cans were made by ordinary tinsmith's methods with lap-soldered joints at the side and the bottom. The side-seam overlap is ½ in. wide and the flange on the bottom is ⅛ in. The lids were made in the same way and fit closely over the canisters with an overlap of ¾ in. Small patches of rust had developed at a few places inside adjoining the soldered seams; they were probably due to traces of flux left after soldering. The canisters were fitted with loose paper linings which had prevented direct contact with the contents. No attempt had been made to seal the canisters hermetically and the lids were easily removed by hand after a little preliminary tapping.

The dried vegetable cans were 8 in. in height and 5¼ in. in diameter, and the meat can was 7 in. in height and 5¼ in. in diameter. The tinplate was 0·0125 in. thick, equivalent to 108 lb. per basis box with a tin coating of about 4 lb.

PART V

SPECIAL APPARATUS USED FOR OPENING CANS

By T. MACARA, F.I.C.

¶ 41 Difficulties to be overcome

At a meeting of the authors, held to decide how the examination of the various canisters and tins should proceed, it was agreed that the first task was to devise an opener which would enable us to effect perforation in such a manner that the pressure of gas could be measured and a sample be withdrawn for analysis without bacterial contamination occurring. Opposite is a description of the apparatus finally approved which gave every satisfaction. All the cans except those of dried Crimean foods were opened in the bacteriological laboratory of the Food Manufacturers' Research Association. After samples had been taken for bacteriological study larger openings were made with ordinary openers and the contents were removed for inspection and chemical analysis. The condition of the interior of the cans was then noted and samples taken for expert examination.

While the withdrawal of gases from the headspace of a can is a routine procedure in some laboratories and is readily carried out with a relatively simple device, the same method could not be employed in opening these historic cans. In these instances it was particularly important that the contents of the cans should be kept free from bacterial or other contamination, as it was desired to examine them, both bacteriologically and chemically, as completely as possible. Further, the character of the earliest can was unknown. It gave the impression of having been made with rather heavy iron plate. The ends were domed and it was uncertain whether these had originally been made in this form or had become so as the result of internal pressure. It was decided, therefore, to

design an entirely new type of piercing and gas sampling device, which would meet all possible conditions likely to arise.

¶ 42 Specification of Apparatus

The device finally adopted is illustrated diagramatically on page 68. In designing it, the following requirements were kept in mind:—

(1) The actual piercing device (*f*) had to be sufficiently strong to pierce the thick plate. It was made of steel, case-hardened at the tip.

(2) It must fit into an outer tubular carrier and be gas tight. To ensure the latter condition, a gland (*b*) was constructed at the upper end. The packing had to be chosen with care as it was to be subjected to sterilisation by dry heat at 150° C. Finally, a tight packing of asbestos string with a very little tallow was found to answer the purpose.

(3) A capillary tube was necessary for withdrawing the gases. This is shown in the diagram by a thick black line (*c*). The arrangement was such that at the moment of piercing the can the inner end of the tube was closed by the piercing device, which could be operated by means of a screw having a slow pitch. A wheel head (*a*) gave ample purchase to pierce the can.

(4) The combined tube and piercer needed supporting in such a manner that, should the domed ends collapse, the device would still retain a gas-tight seal.

This was provided by means of an upper triangular-shaped brass plate (*d*) held firmly in place by the clamping screws. Under this and resting on the outwardly flanged ends of the tube was a powerful spring (*e*). The latter pressed the tube firmly on to a rubber gasket (*g*) placed on the end of the can.

(5) The can had to be clamped rigidly in a carrier.

This was made of wooden discs carrying three tie rods (two only are shown on the diagram).

(6) The withdrawal of the tube, etc., had to be carried out in such a manner that the opening in the can could be kept under aseptic conditions till the bacteriological sample had been taken through the opening.

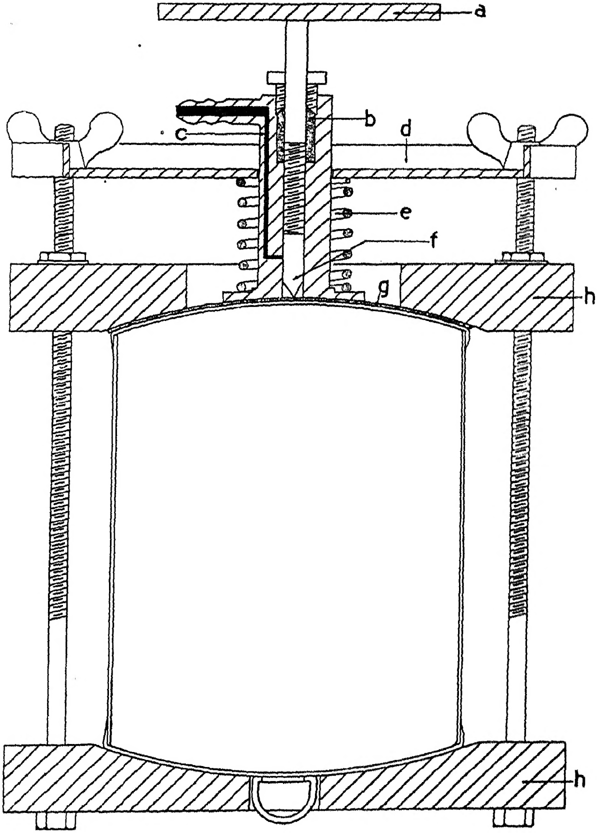
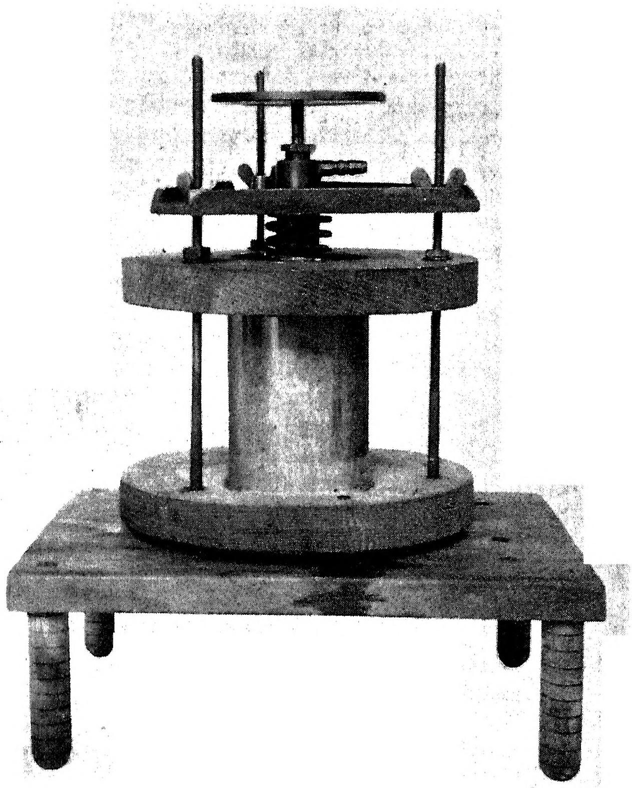


Diagram of apparatus for puncturing cans under sterile conditions, measuring gas pressure and sampling gas

(7) The apparatus must be capable of dealing with either an internal pressure or a vacuum, and it must be possible to evacuate completely the capillary tube and the small space above the can.

¶ 43 The Procedure of Opening

It will be seen from the foregoing that the problem of taking



Photograph of puncturing apparatus

samples of the gases while preventing any form of contamination of the contents was by no means a simple one. The apparatus was built to our specification by Mr. A. P. Kearney, mechanic to the Department of Physiology and Biochemistry, University College, London. The actual procedure was briefly as follows: After appropriate sterilization of the surface to be punctured, the can was firmly fixed between the two wooden discs (*h*) by tightening the screws (*j*) on the three tie rods. The sterile rubber gasket (*g*) was then placed in position and the sterilized piercing device was rapidly

fixed and firmly clamped down, thus compressing the spring, until it was certain that the junction at (*g*) was gas-tight. The outlet tube (*c*) was then connected through a T-piece to a Toepler mercury pump. The capillary tube and the space were evacuated as completely as possible. As soon as the manometer showed the absence of any leakage the can was pierced by slowly screwing down the wheel head (*a*). On withdrawing the point (*f*) past the opening of the capillary tube, the pressure inside the can could be measured and a sample of the gases withdrawn for analysis. The general set-up of the apparatus is shown on the previous page.

The first can to be examined was the Parry can of "roast veal" (see p. 35). We had some misgivings whether the apparatus would puncture what we believed to be a stout iron sheet. Fortunately, the device worked perfectly, the only disappointment being that the pressure of gas inside this can was so high that it could not be measured. It was also used successfully for opening the can of "carrots in gravy" and Libby's tinned tripe (see pp. 39 and 43).

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